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OBSERVATIONS ON PREGNANCY, PARTURITION, AND POSTNATAL BEHAVIOR IN THE BOTTLENOSE DOLPHIN

BY ARTHUR F. MCBRIDE[1] AND HENRY KRITZLER[2]

The observations reported in this paper were made during the interval 1939–1950, at Marine Studios, Marineland, Florida. Four species of dolphins (the bottlenose dolphin, *Tursiops truncatus* Montagu, the long-snouted dolphin, *Stenella plagiodon* Cope, the common dolphin, *Delphinus delphis* (Linnaeus), and the pilot whale, *Globicephala brachyptera* Cope) have been exhibited at that institution under conditions somewhat simulating the natural environment. The data represent an accumulation of what may be termed incidental observations, the nature of the exhibit rendering experimental control impossible. The dolphins are shown in a circular tank, seventy-five feet in diameter and about fifteen feet deep at the center. Glass windows looking in from corridors in the wall permit observation of what transpires beneath the water surface. In a few instances, observations were made on specimens in isolation, furnishing evidence which in many cases corroborated deductions based on data gathered from the large tank.

Pregnancy in cetaceans has been under human observation for some time, most of the material being studied on whaling ships and at whaling stations. A few critical morphological studies of placentation and pregnancy in small cetaceans have been reported. A brief note on parturition in the harbor porpoise, *Phocaena phocoena*, was published in 1914 (James, Proc. Zool. Soc. London, 1914: 1061–2). This was a stillbirth which took place in the Brighton Aquarium, England. But, as far as we know, it is only at Marine Studios that living cetaceans have been under continuous observation during pregnancy, parturition, and postnatal development.

Pregnancy.—Six pregnancies which terminated in abortions or in stillbirths and five which resulted in the birth of normal young have come under our observation. In three of the latter, conception took place in captivity. Two of the normal dolphins conceived in captivity were borne by the same parent, the interval between these births being two years. One of the successful pregnancies is known to have been the first of the mother concerned, since she was less than half grown and probably only recently weaned when captured. Comparing the

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size of this female at capture with that of young dolphins of known age, it seems very likely that the female bottlenose dolphin becomes sexually mature at four years of age, and may bear her first infant in the spring of her fifth year. Every pregnancy observed by us has produced but a single stillborn or normal infant.

Mammals which are well cared for in captivity are almost always heavier than their wild counterparts. Yet it is quite simple to distinguish a dolphin in the latter half of pregnancy from one which is merely well fed. The abdomen becomes greatly distended and the abrupt "step" where the ventral profile passes posteriorly through the inguinal region to the insertion of the caudal peduncle becomes more prominent than in the non-pregnant female. In the male dolphin, this break in streamlining does not exist. The vulva of the gravid dolphin becomes puffed and wrinkled as term approaches. Her navel all but disappears. The abdomen, when viewed from the rear, develops a pronounced disproportionate swelling on the left side. In advanced pregnancies, we have seen evidences of movement of the fetus within the uterus, shown by sudden flickers of motion on the parental abdomen just anterior to the groin on the left side. A diver reported feeling movement of the fetus as he stroked the side of a particularly tame pregnant dolphin. This occurred three months before term. In one pregnancy, we observed what we take to be evidence of the fetus reversing its flexure. This was manifested by the sudden appearance of a pronounced bulge on the left side of the posterior abdominal wall. Bulges of this sort have never been seen by us in other dolphins except during parturition. We interpret the appearance of this transitory prominence as being due to pressure on the relaxed parental abdominal wall by the snout of the fetus as it shifts from sinistral to dextral flexure or *vice versa*.

We have observed false labor in one dolphin; this phenomenon occurred repeatedly over a period of several days, about seven weeks before delivery actually took place. It was characterized by straining and distension of the vulva in exactly the same manner in which these occur in parturition. This animal was carrying her second pregnancy initiated in captivity.

From what we have observed, it may be said that until the pregnancy of the captive bottlenose dolphin has run at least half its course, the behavior of the mother is not to be distinguished from that of other individuals. But, as term approaches, although it may yet be four months distant, there develops in her a definite tendency to withdraw from association with others, as much as the limits of the tank permit. In the spring of 1950, one of us kept two pregnancies under close watch. These dolphins spent most of their time swimming around the periphery of the tank side by side, or at least very close together. These two individuals had not previously been close companions since there was a considerable gap in their probable ages. One was at least seven years old and the other between four and five. This segregation from the others, which consisted of one adult male, two other adult females, and three immature specimens of *T. truncatus*, and an adult male *Stenella plagiodon*, was not absolute, as occasional participation in communal play was observed. But the general pattern of swimming together, apart from the others, was noted regularly. Both individuals had long before

learned to jump from the water to accept fish from the hand of an attendant, and they persisted in this, although somewhat erratically, right up to the days on which their pregnancies terminated. One of them had become accustomed to playing fetch with objects thrown into the tank, and it is noteworthy that her interest in this sort of play diminished as term approached.

An event which occurred two months before these pregnancies terminated showed that the mother dolphin is psychologically prepared for the care of the young some time before parturition takes place. A male dolphin, not more than two weeks of age, found on the beach nearby, was placed in the tank. Its thinness indicated that it had been separated from its mother for some time. But it could swim well and it immediately sought out the two pregnant females, choosing one as its foster parent. It attempted repeatedly to suckle, locating and taking the nipples expertly. The adult invariably slowed down when this happened, just as she would if she were nursing her own infant. That these attempts were futile was proven by postmortem examination of the infant's stomach, which contained no trace of milk. Between these abortive attempts at nursing, the two pregnant females protected the foundling in the manner which we have observed after each of the normal births.

Parturition and parental behavior.—Six dolphin pregnancies—five *Tursiops* and one *Stenella*—had terminated in failure in the tank at Marine Studios before a normal birth was achieved. In retrospect, it seems likely that these abortions and stillbirths could be attributed to mishandling in capture, malnutrition, and in one instance, an irregular delivery resulting in strangulation of a normal fetus. The behavior of the parents during and after these unsuccessful deliveries has been reported elsewhere (McBride, Nat. Hist., 45: 16–29, 1940), but it seems worth while to review the outstanding features here.

With one exception the abnormal *Tursiops* births were much prolonged, ranging from six to more than nine hours in duration. The exceptional case was clearly a miscarriage, an incompletely developed fetus being extruded in thirty-two minutes. The one *Stenella* birth consumed less than two hours. This was the failure due to irregular delivery alluded to in the foregoing. Since the first and second normal *Tursiops* births required, respectively, only twenty-three and twenty-one minutes, it was thought that any birth lasting much more than an hour was almost certain to produce a dead fetus. This was disproved when the third normal *Tursiops* was born, parturition in this instance lasted one hour and fifty-seven minutes. It seems likely, then, that, within limits, it is not so much the actual time consumed that determines success or failure, as whether or not the fetus is speedily expelled once the posterior portion of its trunk is free and the umbilical cord is stretched taut.

In all five cases of abnormal *Tursiops* birth, the mothers swam about the tank a great deal and made efforts to avoid other dolphins as parturition progressed. During the longest birth, the mother even took food although the fetus was only partially expelled. During the early stages, the *Stenella* birth progressed rapidly, the mother doing no more swimming than was needed to maintain her position in the current. It was only after delivery was arrested and the apparent strangu-

lation took place that the mother began swimming rapidly about the tank. During this period, which lasted 29 minutes, the fetus seemed to be hung up by its left pectoral fin. When the flipper was freed, the birth was further delayed as the mother continued to swim about in an excited manner, the fetus hung by its head only and the umbilical cord stretched taut. When the fetus was finally expelled it was quickly retrieved by a diver and, although it never moved, its heart beat could be detected for several minutes.

In every birth observed by us, the instant the fetus fell free, the mother whirled about face. This was interpreted at first as an effort on the part of the parent to sever the umbilical cord by biting it as do many terrestrial mammals. That this is probably an incorrect evaluation is shown by the fact that the cord has always broken within four inches of the body of the fetus when not more than two or three inches of the placental end yet protruded from the vagina. Further, the adult dolphin cannot flex its body enough to bring its snout to its pelvic region. It seems likely that this whirl about-face serves to induce the cord to break as the freed fetus dangles on it, and to bring the mother into position where she can help the infant to the surface should assistance be necessary. In several of the stillbirths, the parents actually attempted to raise their dead young to the surface. When one stillborn infant sank to the bottom, the mother endeavored to raise it by grasping a pectoral fin with her jaws. In passing, it should be mentioned that we have seen a mother dolphin try to raise her dead, six-month-old infant from the bottom by grasping at its body with her pectoral fins.

The first normal birth was made manifest several days before parturition by the withdrawal of the parent from intimate association with the other occupants of the tank. Distension of the genital orifice was noted occasionally during this preliminary period.

Parturition began on February 26, 1947, at 1:05 P.M. The mother remained at the south side of the tank, swimming against the current only enough to maintain her position. It may be mentioned that the south side of the tank with its winter shadow affords as much seclusion as possible since the dolphins ordinarily spend most of their time in the sunlit northern portion. The mother's tail drooped much as it would if she were sleeping near the surface. Frequent spasmodic contraction of the abdominal musculature and distension of the vulva were exhibited. At times, her mouth opened as though she were yawning. A peculiar barking sound, seldom heard in the tank, was repeatedly noted.

The tail of the fetus appeared seven minutes later after a violent distension of the vulva. The dorsal surface of the distal end of the peduncle appeared first and the flukes, which are folded ventrally *in utero*, immediately followed. The fetus lay on its right side, its sagittal plane perpendicular to that of its mother. The tail of the fetus hung motionless. The vaginal distensions and abdominal contractions continued, a little more of the fetal tail appeared with each. The tail was withdrawn a bit, however, each time the mother relaxed. Relaxation between spasms lasted only half a minute or less. The entire fetal tail had appeared by 1:20 P.M.

At 1:22 P.M., the delivery entered what may be termed the critical phase.

The mother had then to expell the fetal trunk with its three appendages, the pectorals and the dorsal fin. The latter, soft at birth in every case observed by us, was folded to the right. The force exerted upon the fetus by abdominal contraction was then increased to such an extent that the mother's body was flexed upward with the tail elevated almost vertically. Her swimming movements were still restricted to the minimum necessary to oppose the circular current of the tank. All other exertion seemed directed toward extrusion of the fetus.

The other dolphins seemed much interested in the proceedings and frequently one or another would examine the mother closely. This seemed not to disturb her, a fact distinctly at variance with what was observed in the stillbirths. During the last six minutes of parturition, repetition of the violent spasmodic dorsal flexure of the parental trunk resulted in the sliding in and out, several times, of the entire fetal trunk.

At 1:28 P.M., a powerful convulsion occurred and the body of the infant (a female) fell free. A cloud of blood (probably very little blood is lost; rapid diffusion in the swirling water creates an illusion of serious hemorrhage where there is none) obscured the view for a few seconds. But the mother made the characteristic whirl about-face as the cord snapped about two inches from the infant's body. Blood flowed from the infant's umbilical cord for a few seconds and then stopped abruptly. By this time the newborn dolphin had already reached the surface and breathed.

The second live bottlenose dolphin born at Marine Studios was conceived in captivity. The birth took place on April 23, 1948. The period of labor consumed only twenty-one minutes, and in no particular did the delivery differ materially from that of the preceding year. The infant born on this occasion was a male, which was accidentally killed when it was six months old.

On May 8, 1949, a bottlenose dolphin which had been captured only four days before bore a male infant, not in the large tank in which the previous births had taken place, but in a shallow receiving tank. The closer confinement imposed on this animal made possible a more detailed examination of the events which are about to be described. The birth was markedly different from the first two in several respects.

When the mother was caught and placed in the receiving tank it was evident that she was very close to term. Two others, a young female bottlenose and a mature male long-snouted dolphin, shared the tank with her. This enclosure measured twenty by forty feet and the water was about four feet deep. The young female bottlenose, which was also newly captured, was apparently not fully weaned for she attempted repeatedly to nuzzle the teats of the pregnant adult. In passing, it should be noted that these dolphins were taken on different days and were probably not mother and daughter. It seemed quite likely that the adult was in milk at least four days before the birth took place.

Few hopes were entertained for a successful delivery, since several of the earlier stillbirths had evidently been caused by damage due to handling during capture of the mothers. The prognosis became even less favorable when, two days before the birth, an accident in an adjacent tank made necessary the complete draining

of the receiving tank, leaving the three dolphins lying on the bare bottom. The tank was refilled after about an hour.

The beginning of labor was announced at 7:15 A.M. by the pregnant dolphin repeatedly raising her tail and whacking the water surface with her flukes. This behaviorism was not seen in the two previous births. Similar behavior has been frequently noted in wild dolphins as they feed, the maneuver being interpreted as a means of frightening the prey. It is possible that it is used by dolphins in labor as a means of frightening away potential enemies such as sharks, although, in the present case, it may have been only incidental to the raising of the tail from the shallow tank as the mother strained to expell the fetus. At 7:25 A.M. the tip of the fetal peduncle and the flukes appeared. No further progress in delivery was achieved until 8:00 A.M. when a little more of the peduncle was in evidence. Throughout this period the mother swam ceaselessly, never stopping in one position as had the two referred to above. Because of the close confinement, the course was a circle of small diameter, always to the left. At 8:00 A.M. a pronounced bulge appeared on the left side of the mother's abdominal wall, suggesting that the fetus was straightening out in the uterus. At 8:02 A.M. four inches of the peduncle protruded from the vulva, and the bulge disappeared. All the while the unweaned bottlenose continued to nuzzle the nipples or the edges of the mother's genital orifice. The entire peduncle of the fetus was in evidence six minutes later. The fetal orientation was with planes parallel to those of the mother. At 8:13 A.M. the body of the fetus rotated ninety degrees to the right. The mother continued circling, occasionally lifting the flukes high and bringing them down with great force on the surface. At 8:16 A.M. she strained in this manner with unusual effort, but without evident effect.

At 8:40 A.M. the posterior portion of the fetal trunk appeared. The inguinal region was then visible, permitting identification of the fetus as a male. It bulged conspicuously, this, no doubt, being due to the force exerted by abdominal and uterine contractions. The orientation remained the same, the fetus lying on its right side. During the next seventeen minutes the mother stretched and strained with renewed vigor, without further extruding the fetus. At 8:59 A.M. the mother stretched and gently rubbed her pelvic region on the bottom. When she relaxed, all but the fetal tail slid back into the vagina. Two minutes later the mother rose to the surface, took a deep breath, and strained with her diaphragm. At the end of this spasm the breath was expelled with a prodigious snort. The posterior portion of the fetal trunk reappeared. The mother again slapped the surface with her flukes.

At 9:06 A.M. the belly of the infant began to show. The dorsal fin, however limp, was apparently delaying delivery. At 9:08 A.M. the mother strained with her diaphragm at the surface again, this time achieving expulsion of the dorsal fin which passed from the vulva at 9:10 A.M. At 9:12 A.M. the infant fell free. The umbilical cord snapped spontaneously with only a trifling loss of blood. The mother whirled as the infant rose to the surface to take its first breath.

Neither of us was present to observe the fourth and fifth normal *Tursiops* births which occurred in May, 1950.

The placenta is not passed for some time after birth of the infant has been achieved. In one instance ten hours elapsed before the placenta was extruded.

The newborn bottlenose dolphin resembles the adult in most respects. Its head, as is usually the case with young mammals, is disproportionately large. The neck shows quite plainly, a feature which is lacking in well-fed adult dolphins. The neck shows as a constriction in starved adults. The dorsal fin of the infant is soft and, in all instances observed by us, folded to the right. The flukes are also soft and curl downward. Both the dorsal fin and the flukes flop perceptibly as the infant swims. These members stiffen and straighten during the first two weeks of postnatal development. Their softness seems in no manner to impair the ability of the infant to swim as rapidly as the mother.

Particularly noteworthy is the presence, on each side of the trunk, of six symmetrically placed vertical creases. These creases lack pigment at birth. They are evenly spaced from the posterior insertion of the pectoral fin to the level of the anus. It is thought that they are produced by orderly wrinkling of the skin as the fetus lies doubled in the uterus. That they occur on both sides is considered evidence that the fetus shifts this flexure from side to side. A single row of seven or eight curled vibrissae is present on each side of the maxillary portion of the snout. These are lost before the infant is a month old, but the follicles are evident throughout life. The eyes are open at birth, and vision seems to be good. The teeth are not yet erupted in the newborn dolphin, but there are present on the gums prominences separated by deep transverse clefts. A tooth arises from each of these by the time the infant is six weeks old. The newborn bottlenose may be thirty-six to forty inches in length and is estimated to weigh about twenty-five pounds.

The newborn bottlenose swims to the surface for its first breath without assistance. During the first few weeks, when it surfaces to breathe, momentum throws its head clear at about a forty-five degree angle and the infant falls back with a light splash. It is not until it is a couple of months old that it acquires the smooth roll which characterizes the respiratory surfacing of the adult. If, for any reason, the mother is forced to swim with utmost speed, the infant can keep up with her, even before it has suckled for the first time. Because of its smaller mass it is forced to beat its flukes more rapidly than the adults do, and this, coupled with its more rapid heat loss, probably accounts for the fact that respiratory surfacing occurs at almost double the adult rate. It is vocal from the moment of birth; the high pitched whistling which all dolphins observed by us use for ordinary communication is very much in evidence. The infant and its mother seem to be in constant vocal communication as shown by the bubbles escaping from their blowholes when whistling is heard.

We have observed certain special behavior patterns which seem to promote survival of the infant during the first few hours or days after birth. For example, it appears that the newborn dolphin is equipped with a tendency to follow, by flanking, an adult dorsal fin. This places it in a protected position, a little above and at one side of its mother's trunk. If there is another adult female in the vicinity, she will usually swim beside the mother with the infant between the two

dorsal fins. The second *Tursiops* born in captivity was spared probable injury incident to savage attacks inflicted on the mother by the sexually aroused males —this birth having occurred during the height of the mating season. In the confusion, it chose as a guidon, not its mother's dorsal fin, but that of a young male *Stenella plagiodon*. Each time an attack occurred, the long-snouted dolphin dashed away, fortuitously leading the infant to safety. When each fracas subsided, the mother sought out the infant and nosed it away from the long-snouted dolphin. The first infant born in the large tank was not so fortunate, and sustained bruises and superficial lacerations before the males were quieted by dosing their food fish with paraldehyde.

When the third infant was just one week old, he and his mother were transferred to the large tank. The young animal was herded through the intervening gate without difficulty, but the mother strongly resisted, apparently because she was reluctant to pass under the walkway over the gate. So the infant found himself in company with a number of strange dolphins for some minutes before he was joined by his mother. By chance, he selected the immature female which was born two years before as the dolphin to follow. She, apparently startled by this novel situation, fled around the periphery of the tank for a minute or two at top speed, which for this species may exceed twenty miles per hour. The week-old infant seemed to have no difficulty in keeping pace with her. When the mother entered the tank, she joined her infant only to be whisked away from him, surrounded by all the other dolphins. It was then that we witnessed a behavior pattern which, if it is typical of young dolphins who suddenly find themselves separated from their mothers, has definite survival value. The infant began circling rapidly, at the surface, about a diameter of roughly six feet, in exactly the position at which he was last in contact with his mother. All the while he whistled, pausing in this only to exchange breaths. The circling and whistling did not cease until his mother found him.

As we have mentioned in the foregoing, the mother of a newborn infant will almost invariably be assisted in its care and protection by another mature female. The mother of a stillborn infant may be thus aided in her efforts to raise it to the surface. The helping female will share with the mother the responsibility of warding off attacks by adult males, if these occur. This solicitude for the safety of the offspring, shown by females other than the mother, persists for several weeks after birth. Whenever excitement is evoked, as, for example, when a new large specimen of any sort is introduced into the tank, all the dolphins usually swim rapidly around the tank in tight formation. The mother, the infant, and the assisting female find themselves in the center of this assemblage.

An example of the concern with which the mother cares for the infant was exhibited in the case of the male born in the receiving tank, which, as we have seen, is equipped with a walkway over the gate at either end. When the infant was but thirteen minutes old, it swam under one of these overpasses. The mother darted under and, with her snout, guided him back into the center opening. Although the two were not watched continuously during the ensuing week, they were under our observation enough so that we may conclude that the young

dolphin was not again permitted to venture under the walkways. Each time he was seen to approach one, the mother dipped under him and, rising, flipped him away from the apparent danger with her snout. Nor was he permitted by his mother to approach the tank wall, against which he collided just once, when he was but a few minutes old.

The infant born in 1947 started searching for her mother's teats one and a quarter hours post partum. The object of search was found thirty-two minutes later, and nursing proceeded. Four hours elapsed before the 1948 male began to seek nourishment, but he found a nipple in fifteen minutes. The 1949 specimen started to investigate his mother's inguinal region only nine minutes after birth, but nursed for the first time four hours later. He would probably have nursed sooner were it not for the fact that the half-weaned female referred to above interfered with his progress.

When the very young dolphin suckles, the mother rolls over on one side and glides slowly during the few seconds which pass while the nursing takes place. The infant swims gently, just enough to keep pace with the parent's momentum. The extruded nipple is grasped between the palate and the extended, grooved tongue, the mouth being held slightly agape. The edges of the infant dolphin's tongue are fimbriated, the fringe apparently serving to assure a water-tight seal. Dolphin mammae pour their secretion into spacious sinuses and the contents of these are expelled by contraction of the abdominal musculature as soon as the nipple is grasped by the infant. Each suckling lasts, therefore, only a few seconds. A little cloud of milk often disseminates into the water as the infant relinquishes its hold.

Nursing is rather frequent during the early weeks and becomes less so as the infant grows. During the first two weeks, nursing periods are spaced at intervals of ten to sixty minutes with an average of twenty-six minutes. During each period, the infant may suckle only once, or as many as nine times. It may either rise to the surface to breathe between sucklings, or it may try each of the two nipples before taking another breath. The mother may not necessarily roll over on her side to accomodate the very young infant as it suckles, but if she does so, this is dispensed with after the second week and the infant is forced to roll from then on.

Postnatal behavior of the infant.—During the first month, the infant dolphin stays very close to the mother. When the two swim, the young one takes position beside and slightly above the parent. The first trend away from this pattern is shown by the tendency of the infant to swim about its mother's head, rubbing its body on her. This maneuver is reminiscent and possibly prophetic of the manner in which offshore and pelagic dolphins play about the bows of ships. We have seen adult bottlenose dolphins play in this manner about right whales, *Eubalaena glacialis*.

When the mother sleeps, the infant usually takes position under her tail, the top of its head just touching the posterior extremity of her abdomen. McBride and Hebb (Jour. Comp. Physiol. Psych., 41: 111–23, 1948) have described a sleeping attitude which was in general use in the tank at the time at which their observations were made. Since then, this sleeping at or near the surface has given

way to sleeping near the bottom. The change was induced by the introduction into the tank of a powerful spiral current which tends to force all floating debris (and, incidentally, sleeping dolphins) toward a central drain. The dolphins now get their rest in short "cat-naps," each lasting only as long as they can easily hold the breath, a period of from thirty to forty seconds. The body is oriented toward the fast-flowing water with the head down. The current, as it sweeps up over the dorsal surface, holds the animal more or less stationary. When a return to the surface for respiratory exchange must be made, a single sweep of the flukes raises the head so that the current now flowing under the dolphin raises it to the surface. When the mother is sleeping in this manner, the infant sleeps under her tail, the two rising together to breathe.

As McBride and Hebb have reported, the young female born in 1947 did not begin to play until she was about five weeks old. Their proposition that infants not suffering from injuries may begin playing at an earlier age was well taken. Both of the males born subsequently began to steal away from their mothers when they were no more than two weeks old. At first, these ventures were restricted to swimming about the heads of other dolphins. Later, as they achieved greater confidence, they began to imitate the adults in teasing the fishes and indulging in games of chase with other dolphins. These early assays at play generally take place while the mother is resting. McBride and Hebb describe how, after a while, the mother of the 1947 infant would take it away from any other dolphin with which it might be playing. The mother of the 1949 male was, as we have already pointed out, practically a wild dolphin. She was, therefore, very shy and did not mix with the other adults. When, in her attitude of rest, she discovered the absence of her offspring, she would not go after it, but would stay in the resting position and whistle. That it was she whom we heard whistling was shown by the stream of tiny bubbles escaping from her blowhole each time a whistle was heard. She would continue to whistle until the infant returned. As soon as his head touched her pelvic region, the whistling stopped.

Play, involving the nipping of fishes, chasing them in and out of their rock crannies, and mouthing feathers and other floating articles, has been described by McBride and Hebb. They have alluded to the fact that imitating the other dolphins in the tank is largely responsible for the development of play in the infant. The apparent precociousness shown by the 1948 and 1949 infants may have been due only to the fact that they had a more highly developed "culture" of play patterns accumulated by the adults and the 1947 infant to imitate. Then, too, as we have previously noted, these two were spared the injuries which may have retarded the maturation of play in the 1947 female.

During the spring of 1949, the 1947 female had been taught to come when called by the observer. The signal was given by vigorously agitating the water with one hand; this produced a swishing sound which we assume was heard by the dolphins since we could distinctly hear it with a hydrophone. The two-year-old female was rewarded for coming by being stroked and petted and by being engaged in a game of fetch with an inflated inner tube. The latter was reward enough in itself, since the dolphins frequently initiated the game without induce-

ment. This was effected by the animal throwing a tube over the railing, then standing by with her head out of the water waiting for it to be thrown back. Before long, the 1949 male learned to come at the signal, but he passed his second month before he permitted himself to be touched by the observer. He would come close to a hand thrust into the water, but if it moved toward him he would dart away, whistling. Apparently curiosity impelled him to return, which he often did, promptly. He was much less than a year old when he learned to retrieve the inner tubes. The 1947 female would often retrieve two at a time.

All the dolphins play with the inner tubes. They usually rise up from underneath, spear the rings with their snouts and then, as momentum carries their heads above the surface, hurl the tubes into the air. The 1949 male took to this play so readily that at six weeks of age he had already thrown a tube over both rails into the grounds outside. It is significant that only immature dolphins have learned to play fetch, and doubly so that this game was originated by a dolphin, not by its human attendants.

Dolphins are very fond of rubbing their bodies on various objects, so a backscratcher, constructed of three street sweeper's brushes fixed to a slab of rock with the bristles directed upward, was installed in the tank. The young dolphins took to rubbing themselves on these brushes as soon as the adults discovered their purpose. The 1947 female, at the age of two years, became so fond of being caressed by the observer that she would frequently rear cautiously out of the water to rub her chin on the knuckles of his clenched fist. It is interesting to note that when the young dolphins seem impatient with interruptions in play at fetch with inner tubes or pelican wing quills, they express it vocally with the head out of the water, emitting a high pitched grating noise from the blowhole.

We have seen many instances of what may be termed truly remarkable play patterns developed by the immature dolphins. An example, which may be considered evidence of a high degree of intelligence, is the reaction of a young dolphin to the following situation. It was engaged in a game of fetch, the object being passed back and forth was a large, wet, pelican feather. The observer threw it to the dolphin, which promptly returned it by flipping it upward from the tip of its lower jaw. Once the feather failed to clear the rail when thrown by the dolphin, and stuck to the wall above the water level. Picking the feather off the wall with the mouth was precluded by the fact that the dolphin's chin juts anteriorly of the opening of the mouth itself. She neatly solved the problem by rising above water level and wiping the feather back down into the water with the side of her head, there to pick it up and resume the game. This solution was retained and used frequently thereafter.

Another play pattern requiring cerebral development of this order was performed repeatedly by the 1949 male when he was less than a year old. He would take a piece of squid or food fish and drop it on the floor of the tank about eighteen inches from a rock cranny inhabited by a red grouper, *Epenephelus morio*, and then back away. As the grouper emerged to take the bait, the young dolphin would dart in and seize it, carrying it away as the grouper fled back into its cranny.

Yet another play pattern involved use of the jets, which are blasts of new sea water forced under great pressure into the tank from nozzles situated near the bottom. The same young dolphin was frequently seen to thrust his snout into one of these blasts from the side, there to release a feather which he would then chase as it was carried away by the current.

This was elaborated upon by the 1947 female at the age of three years. She would release a feather into the eddy adjacent to the jet and then back away and wait, with her mouth open, to catch the feather as soon as it passed into the current and was swept to her.

It may be said that the young dolphins are sexually very precocious. Attempts at copulation with older animals of either sex occur at any age from six weeks onward. Masturbation is frequent, particularly in females of any age. Anomalous sexual behavior is very common in confined animals, and it is open to question whether or not the sexual precociousness exhibited by the young dolphins is merely a manifestation of their tendency to imitate anything they see the older animals do.

The 1947 female showed signs of functional sex interest at three years, but it seems likely that she will not be ready to initiate a pregnancy until the spring of her fourth year.

The 1947 female did not begin to show interest in solid food until she was eleven months old. This was first shown by her taking a food fish and playing with it, either by mouthing it under water, or by throwing it into the air, for hours at a time. When she first swallowed a fish is not known, but she was eating a few each day after her twelfth month. She did not cease nursing altogether until she was eighteen months old. This was fortunate, for at fourteen months she was stricken with food poisoning due to spoiled fish and for a period of two weeks subsisted on milk only. The 1948 male, which was killed accidentally at six months of age, had not yet begun to show interest in solid food. The 1949 male began to eat small bits of squid (which were not available to the preceding two infants at a corresponding age) when he was but five months old. At six months he was eating one or two whole squid (*Loligo*) daily. He began to play with food fish at eight months.

Discussion.—We have never seen a functional mating. Much homosexual copulation between males has been observed and we have frequently seen heterosexual copulations, the male of such pairs invariably being immature—probably too young to initiate a pregnancy. Four pregnancies—one of them a failure—were commenced in the tank. The matings which generated these pregnancies were probably performed at night. McBride and Hebb have alluded to the fact that when there is more than one adult male in the tank, matings cannot apparently take place during the day because of competition. The two infants born in May, 1950, were carried by the only two females which were receptive during the preceding spring. That these births took place thirteen months after the adult male population in the tank was reduced to one individual seems rather significant. The presence in the tank of one adult male and several adult females and their young seems more closely to approximate the situation which exists

in the wild. On many occasions we have seen small groups of bottlenose dolphins enter the estuaries with the rising tide. These groups almost always consist of a single adult male and three to five adult females, some of which may be followed by young in their first or second year. It is quite easy to determine the sex of wild bottlenose dolphins by the shape of the dorsal fin. It seems probable, therefore, that the basic social unit in *Tursiops* is a family of this sort, and that normal pregnancies will occur more regularly in the tank at Marine Studios as long as this pattern is adhered to.

As we have seen, the height of sexual activity in the captive dolphins occurs in April. During that month in 1949, the three male bottlenose dolphins fought with such viciousness that the life of a young pilot whale, then in the tank, was considered in peril. It was for that reason that two of the males, one of which was quite old, were released. If the pregnancies resulting in the two normal births which took place in 1950 were not initiated by the remaining male, then the gestation period of *T. truncatus* exceeds thirteen months. If they were commenced by matings with the remaining male, it is more than likely that these took place in late April or early May, which would point to a gestation period of at least twelve months.

Whether gestation consumes eleven, twelve, or thirteen months is not so important as the fact that it is relatively long for carnivorous mammals. The large herbivorous mammals usually have long pregnancies, and the adaptive significance is the same as in the case of the dolphin. The young ungulate must, within a short time after birth, be able to follow its parent as she moves from one pasture to another. The young dolphin, unlike the terrestrial carnivore which may lie helpless in a den or hollow tree, must be able to swim with its mother from the instant of birth. The long period of gestation, then, carries the dolphin far enough along in its development to be able to survive.

It is not known how long dolphins live. The answer to this question may eventually be obtained at Marine Studios, since there are in its tank several dolphins of known age. It seems highly improbable that they will prove to be characterized by great longevity. It is difficult to see how an organism with as high an energy demand as that of a dolphin could survive for very many years. Yet dolphins cannot be said to be characterized by a high reproductive rate, since they apparently do not attain sexual maturity at an age comparable to that of terrestrial carnivores, and, as seems to be the rule among Odontocetes (see Slijper, Bijdr. t. d. Dierk., 28: 416–48, 1949), they are uniparous. Furthermore, we have not yet seen a single female produce young at an interval of less than two years. It is possible that in the wild state the bottlenose dolphin may bear young every year, since our data show that a pregnancy may be initiated while the mother is still nursing her previous offspring.

The disproportionate swelling and the appearance of movement on the left side of the maternal abdomen in late pregnancy, together with the bulge which appears suddenly on the same side during parturition, are consistent with the observations made by various investigators (see Slijper, *loc. cit.*) that implantation in the left uterine cornu is the rule among Odontocetes.

The same reviewer points out, on the basis of his observations on a pregnancy in the harbor porpoise, *Phocaena phocoena*, that, although the snout of the fetus is directed toward the tail of the mother, the fact that its head lies in the tubal end of the folded uterine cornu and its tail in the cervical makes tail first presentation at birth inevitable. All cases of Odontocete parturition which have been observed entirely or in part have been characterized by caudal presentation.

Wislocki and Enders (Amer. Jour. Anat., 68: 97–125, 1941) have described placentation in the bottlenose dolphin. As shown in their diagram (Fig. 1, p. 99), the fetus lies in the left horn of the uterus. They point out that it lies in cephalic presentation, but it will be noted that the snout is thrust into the tubal end of the left cornu, just as in the case of Slijper's *Phocaena*. The tail of this bottlenose fetus is folded to the left as is the dorsal fin. It would be interesting to know whether or not the tail of the fetus described by these authors was displaced, in handling, from a cervical orientation to within the cornu as shown in their figure. It is probable that they are not justified in asserting that their fetus lies in cephalic presentation, merely because its snout is oriented toward its mother's tail. More likely, this orientation results, as in Slijper's *Phocaena*, from a caudad folding of the left uterine cornu, and that caudal presentation would have occurred had this fetus been born. Their sketch and their diagram in Figure 2 show plainly how thin the chorion and endometrium are in the antimesometrial portion of the left cornu, providing, as it were, a container flexible enough to permit reversal of flexure which we submit is responsible for the bilateral vertical creases which appear on the newborn dolphin. That the dorsal fin of their specimen was folded to the left is remarkable since in every newborn dolphin which has come under our observation the dorsal fin was folded to the right. If, as Wislocki and Enders suggest, the dorsal fin and the tail are always folded to the same side, right or left, this may be construed as additional evidence in support of our contention that reversal of flexure occurs. But it must be pointed out that the dextrally folded dorsal fins of the normal newborn dolphins were so folded that, although they flopped perceptibly as the infants swam, they never flopped over to the left side, but slowly straightened upward during the first weeks of postnatal life.

Our observations on six abnormal and three normal parturitions indicate that once the umbilicus of the fetus has emerged from the vagina, delivery must be accomplished with dispatch lest the fetus be stillborn. In all three normal births witnessed by us not more than six minutes transpired between appearance of the umbilical cord and completion of parturition. During the *Stenella plagiodon* stillbirth, the delivery was rapid up to this point; the ensuing delay was apparently occasioned by the left pectoral fin being caught, probably by the maternal pelvis. It is significant that during the early, rapid portion of this birth, the behavior of the mother was similar to that of the first two bottlenose dolphins who bore normal young in the tank. She swam only enough to maintain her position with reference to the current. When delivery was arrested and the umbilical cord was stretched taut, the fetus started beating its tail, suggesting that its placental circulation was impaired. When this stopped, the behavior of the par-

ent changed to that seen in the other stillbirths and abortions; she commenced swimming rapidly and erratically about the tank. Then, too, she now showed for the first time during the birth, distress at the approach of other animals. The behavior during parturition, of mothers of the two categories, is so evidently different that we are inclined to conclude that in some way the mother is capable of sensing when abnormality in parturition is taking place, even though extrusion of the fetus is not yet completed.

Wislocki and Enders (*loc. cit.*) report that the umbilical cord of their near-term specimen measured 33 cm. from the umbilicus to the bifurcation of the umbilical vessels. They also describe an exceedingly intimate interdigitation of the chorion and endometrium in the tubal end of the left cornu and in the right cornu resulting in placentomata which resisted separation of fetal from maternal tissue by manipulation. This and the relative shortness of the cord render it absolutely necessary that, when the fetus is finally extruded, the cord be snapped off short. The cord has always broken at less than 10 cm. from the umbilicus and never more than that protruded from the vagina. Thus, the whirl, which seems invariably to characterize the behavior of the mother at the instant of birth, can serve no purpose other than to aid the spontaneous breaking of the cord and to place her in position to help the infant if aid is needed. The fact that as many as ten hours may elapse between birth and extrusion of the placenta is due, no doubt, to the close interlocking of chorial and endometrial villi in the extremities of the placental area.

In their discussion relative to the intelligence rating of the dolphin, McBride and Hebb (*loc. cit.*) give particular emphasis to the significance of play patterns exhibited by these animals. At the time at which their report was rendered, few data on the play of very young dolphins were available. The extraordinary play behavior, the aptitude with which young dolphins respond to training, and the precocious sex play outlined in the present paper serve only to support their suggestion that, in respect to emotional and motivational behavior, the dolphin appears to fall somewhere in the range of development of dog to chimpanzee.

Summary.—Six stillbirths or abortions and five normal pregnancies in dolphins have been observed. In each case only a single fetus was delivered.

The external appearance and behavior characteristic of pregnant dolphins are described. False labor occurred seven weeks before term in one pregnancy. External evidence of fetal movement was seen. A tendency of the gravid female to withdraw from the herd develops late in pregnancy. The fostering of a foundling showed that pregnant dolphins are psychologically prepared for care of the young well before term.

Abortive parturition in dolphins is generally prolonged, consuming as much as nine hours. Generally, normal births are rapid, particularly after the posterior portion of the fetal trunk is extruded and the umbilical cord is stretched. Tail-first presentation is the rule.

At the instant of birth, the mother whirls about-face. This is interpreted as a means of breaking the umbilical cord and of getting the mother into position to help the infant to the surface. Normal infants rise to the surface for the first

breath without assistance. Mothers of stillborn infants attempted to lift their young to the surface. As many as ten hours may pass before the placenta is expelled.

The newborn dolphin differs from the parent in appearance in respect to its large head, evident neck, soft ventrally folded flukes, and dextrally folded dorsal fin. Bilaterally symmetrical creases, six on a side, which are thought to be caused by intra-uterine folding of the fetus, appear on the newborn dolphin. Vibrissae are present. Teeth are not yet erupted. The eyes are open and, since both young and parent are extremely vocal, hearing is considered functional at birth. The infant swims expertly from the moment of birth.

The parent and other adult female dolphins show great solicitude for the protection of the newborn young. The young dolphin seems to be endowed with special behavior mechanisms which have survival value. Behavior which may be characteristic of the lost infant was observed.

Nursing commences very soon after birth and continues, in captivity, as long as one and one-half years. Suckling is very brief, the milk being expressed from mammary sinuses by musculature contraction as soon as the infant takes a nipple.

At a very early age, the infant dolphin begins to leave its sleeping mother to play. Cautious at first, the young one develops more and more elaborate play patterns as it acquires confidence. Young dolphins have proven to be susceptible to being trained by humans. At times, the dolphins may initiate play involving human participation. They become very fond of being stroked and petted. Their play patterns show remarkable ability to solve problems and to adapt to particular situations, which are not likely to be encountered in the wild state. They are precocious, sexually. Much of their behavior seems to be imitative, but adaptibility is also apparent.

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THE WHITETAIL DEER OF TOMHEGAN CAMPS, MAINE, WITH ADDED NOTES ON FECUNDITY

By Ralph S. Palmer

The data in this paper pertain mainly to a doe *Odocoileus virginianus borealis* Miller and her offspring at Tomhegan Camps, in the wild land township of Tomhegan, Somerset County, on the western shore of Moosehead Lake, Maine. Other breeding data for the species over a considerable portion of its range are gleaned from the literature and correspondence.

Tomhegan Camps was built in 1913 and no hunting was allowed in the vicinity. As a result, a variety of wildlife became unusually tame there. Deer, mainly does and their fawns, were seen about the camp cabins almost every day and some could be approached closely. During the first few years of the camp's existence Mr. R. P. Spinney, proprietor, attempted to kill all foxes, wildcats, owls, hawks, and other predators. Later this policy was changed to one of no predator control, except for the killing of an occasional rat or firing a charge of birdshot at a marauding bear to drive it from camp. Occasionally a raccoon has to be live-trapped and banished to Farm Island out in the lake. There are no fences at Tomhegan Camps. No animals are caged. There is considerable supplemental feeding and salt licks are provided.

The camp area is part of a 700-acre State Game Preserve, established in the early 1930's. There are practically no year-round human inhabitants in the relatively unbroken forest extending northwestward to the Canadian boundary. The rather poor and acid soil of Tomhegan Game Preserve and vicinity supports a forest of mixed coniferous and deciduous woodland with a varied understory beneath the older deciduous trees. On the preserve there are two springs, several small brooks, and numerous boggy places; it is bordered on two sides by Moosehead Lake. Even in time of drought water can be found easily on the preserve. Around the camps on Tomhegan Point the understory and part of the forest overstory have been cleared and here the rocky and uneven ground supports a crop of grasses. There is hardly any aquatic vegetation along the rocky shoreline of the point.

Since Mr. Spinney's death Mrs. Spinney and daughter Marjorie have operated the camp and the latter has been especially successful in gaining the confidence of various mammals. Mr. Harward W. Cram (deceased March 27, 1950), a guest at the camp annually from 1914 on and resident there for seven months of the year beginning in 1927, kept notes on his observations on deer and other wildlife during his stays at camp through 1949. Given below are reproductive data on Diana, best known of the camp's deer.

1934.—Early in June, Warden Bert Tupper brought to Tomhegan Camps a doe fawn about two days old. She was christened Diana, reared on a bottle for a few weeks, then given complete freedom. She soon was adopted by a wild doe that had frequented the camp area with her fawns for some years. The wild doe was known as Mother and in 1934 had one buck fawn, named Pan. For two years Diana and Pan were close companions.

1935.—Diana one year old and still going with Mother and Pan.

1936.—June 7, Diana gave birth to a *single* buck fawn, Pan, Jr. From that time on Mother never was seen again.

1937.—May 24, Diana had her first set of *twins*, White Socks and Brown Socks (bucks).

1938.—June 5, Diana had her second set of *twins*, Dandy and Bambi (bucks).

1939.—May 25, the third set of *twins* born, Six and Seven (bucks).

1940.—May 28, Diana had her first set of *triplets*, Tom, Dick, and Harriet (the last mentioned being her first doe fawn).

1941.—June 8, Diana had her second set of *triplets*, Gin, Whiskey, and Soda (bucks).

1942.—May 29, a fourth set of *twins* born, Hale and Hearty (bucks), and on May 21 Harriet, Diana's only daughter, born in 1940, had her first fawn.

1943.—June 5, a fifth set of *twins*, Don and Dee (buck and doe).

1944.—June 3, a third set of *triplets*, June, Jean, and Jane (does).

1945.—June 11, a fourth set of *triplets*, Skid, Skidoo, and Mike (a doe and two bucks).

1946.—June 10, Diana fawned. She is known to have had at least *twins*, but only one doe fawn, Trudy, survived. About June 6, June, Jean, and Jane (the 1944 triplets) also fawned. Only June's and Jean's single buck fawns survived.

1947.—June 9, Diana gave birth this date, as the change in her appearance clearly indicated. It was not known how many fawns she had as none survived to be led to camp. Between June 8 and 10, June, Jean, and Jane also fawned. Only June's doe fawn and Jane's buck fawn survived.

1948.—June 1, Diana had her seventh set of *twins*, Pomona and Paula (does). In the period June 6 and 10, June, Jean, Jane, and Trudy fawned. It was Trudy's first fawn and born on her second birthday, June 10.

1949.—May 31, Diana failed to show up at the kitchen door this morning and Marjorie Spinney was positive that at least twins could be expected. About 5 P.M. Diana appeared with one fawn only a few hours old. It was barely able to stand. About 9:30 A.M. the next day, June 1, Diana had two fawns following her. On June 2, Marjorie picked up one of the fawns. It struggled a bit, but when placed on the ground remained to be stroked and petted. Diana watched this carefully, but did not attempt to interfere or defend the fawn as she used to do in years past. The experiment was repeated the next day with the other fawn, which was not quite as tame as the first. Both later proved to be bucks.

On June 3 or 4 Marjorie saw Diana going west by the pump house, followed closely by two fawns. Marjorie turned her back for a few seconds and, when she looked again, Diana still was heading slowly west and the two fawns were out of sight, but a fawn was catching up with Diana and coming from the spot where the doe with two young had first been seen. On June 12 Diana was standing near the spot where Marjorie believed she had seen triplets and a young girl (a camp guest) went over to Diana to offer her sweets. She found Diana standing by a fawn lying in the grass; thinking the fawn was asleep she stooped to pet it and Diana kicked viciously. The fawn had been dead a few hours at most. The car-

cass showed no injury; unfortunately the sex was not noted. Considering that a doe will avoid or kick, rather than associate with or defend, another doe's offspring, it seems safe to conclude that Diana had *triplets* in 1949. This is stated with the knowledge that Severinghaus (1949*a*) reported two captive nursing does that each adopted a fawn shortly after losing a twin and that unconfined deer may adopt fawns under some circumstances. Diana herself, when less than two months old, was adopted by Mother.

Jean fawned the first week in June and Jane at a later time, the exact dates being unknown.

Diana's total to date is 19 buck and 9 doe fawns plus 3 or more (sex unknown) that failed to survive. Thus we have a total of at least 31 fawns in 14 years. Included are 6 known sets of twins and 5 of triplets.

Behavior of Diana toward her progeny.—When Diana fails to come to camp for one whole day she is fawning, for the next day she brings one fawn to camp and the others usually one at a time on succeeding days. In 1944, however, nearly three weeks elapsed before the third triplet was brought to camp. She does not become noticeably wilder at the time she fawns, but her disposition is not as good as usual when the fawns are small. She drives other deer, also humans, away from her fawns, although a noticeable 'softening' of her reactions (even when she has small fawns) has come with advancing age. In 1939 she left a very young buck fawn about ten feet from Mr. Cram's cabin and the fawn remained there, hardly moving, for several hours. When the fawns are young and she is feeding away from them, she will look up occasionally, stare with her ears pointed forward, and stop chewing—probably looking and listening in the direction where the fawns are hidden.

She always chases her daughters away when they have fawns; the daughters generally wait until their offspring are quite large before bringing them near their grandmother. This has complicated the task of getting fawning dates for the younger does.

When they are yearlings, the young deer show attachment for their newborn brothers and sisters, licking and playing with them if permitted to do so. Diana's offspring associate with her until into their third year, by which time she begins to drive them away and they disappear from the camp area. By this time their own social ties have weakened and they stay less and less together. It should be remembered that two-thirds of the fawns have been bucks which may wander more than does or be more solitary in disposition. No regularity has been noted in the manner of their disappearance, whether singly or collectively. Occasionally, in midsummer and fall, full-grown bucks visit salt licks in camp singly. It has been impossible to determine whether they are Diana's sons, but they do show a degree of tameness.

Especially in the past three or four years, Diana's older offspring in camp have seemed to realize that they can 'stand up' to her more and more and do not permit themselves to be driven from handouts of food the way earlier progeny were driven. Her 'softening' shows in her contacts with humans; she has become more approachable and companionable.

Loss of fawns.—No marked reactions have been noted in Diana and daughters when they have lost fawns, except that in 1949 Diana defended a dead fawn briefly, as noted previously. The does come for handouts, without offspring. In 1947 Mr. Cram found the remains of a fawn some 200 feet from his cabin and 20 feet from the lake shore, near small firs but out in the open, a few weeks after the animal had disappeared. The remains consisted of a little weathered patch of red hair and small bones, which were not scattered; the June grass had grown up through them. Another time the skull of a fawn only a few days old was found near the same place. This locality, called the "maternity center," is a quiet part of the camp grounds some distance west of the cabins and the does seem to prefer it as a place for giving birth to fawns. Even camp cows have dropped calves there. The trees there are fairly mature, mixed deciduous and coniferous, rather openly spaced and with a substantial understory.

Activity during estrus.—No particular change in Diana's behavior has been observed during heat. At this season bucks appear, always coming singly. On a number of occasions a buck has stayed about camp for several days, obviously interested in Diana. In 1940 a 15-point buck stayed about camp and with Diana November 16–20 inclusive. He showed no timidity. One of the camp guests approached within a few feet of him to take pictures when up went the hair on his withers and he appeared ready to charge if approached closer. On November 7, 1941, and for several days thereafter, a fine 14-point buck, promptly named Lochinvar, came and stayed with Diana around the winter cabin. Harriet, a yearling and the only other doe in camp at the time, was much excited by his presence, but he was not observed to pay any attention to her. Possibly they did mate as Harriet fawned the following May. After several days, Diana and Lochinvar disappeared for about 24 hours and she came back alone. Approximately 200 days later (May 29, 1942) she gave birth to twins.

In connection with the foregoing it should be noted that Nichol (1938: 30) found that Whitetails [? *O. v. couesi*] in Arizona are receptive for a few hours to less than a day during one estrus period (if unbred, does have three or four periods at 21- to 23-day intervals) and the gestation period is approximately 200 days. For the northern whitetail in New York State, Cheatum and Morton (1942*a:* 337) mentioned a "maximum 36 hour duration of oestrus" (receptive one day but not the next) and observations on two does showed a recurrence of estrus at 28 and 29 days. The range of gestation periods which these authors observed in their experimental animals was 189 to 202 days, the usual period in the northern whitetail being 196 days or seven lunar months (E. L. Cheatum, personal communication). Recently Haugen and Davenport (1950) have reported on 13 breeding records of penned whitetails in northern Michigan, finding an average gestation period of 204 days (range of 197 to 207¾ days).

Fecundity.—As far as I am aware there are no recorded breeding data for a northern whitetail comparable to Diana's. There are considerable data indicating high fecundity in the species, as follows.

In Missouri a tame doe [*O. virginianus* subsp.] gave birth to two doe fawns in 1900; in 1901 she dropped two more (? sex); in 1902 there were four fawns (?

sex), evidently twins by this doe and singles by her 1900 offspring; by the spring of 1905 the herd had increased to 25 deer, "all the increase of 1 pet doe" (Rodes, 1907: 20).

"It has been scientifically determined that one female white-tailed deer and her offspring in a ten-year period will produce 130 animals, and that two dozen does will have 3,000 descendants in the same period" (Shiras, 1923: 670). The data for making this statement, if any, are not known; the arithmetic is fairly obvious.

At Horseshoe Lake Refuge in Illinois "one buck and three does [*O. virginianus* subsp.], planted in 1933, increased to 250 in 1944" (Leopold *et al.*, 1947: 166).

On the Edwin S. George Reserve, a fenced area of nearly 1,300 acres in Michigan, two bucks and four pregnant does [*O. v. borealis* Miller] were released in 1928 and a deer drive in the fall of 1933 gave a count of 160 head (Hickie, 1937). Knowing the initial and final figure, the average annual rate of increase in this herd over six years was calculated mathematically by Kelker (1947:180) as 1.651; in other words, "an interest value of 65.1% compounded annually." Kelker (*ibid.*, 181) concluded that the fecundity of this herd averaged "exceedingly close to 2 fawns being born to each adult female in the herd."

Kelker wrote: "Such unusual reproductiveness for six consecutive seasons seems improbable. However, if a female had only a single fawn, then the second one of twins must be accounted for by one of two ways—either several adult females had triplets, or many yearlings at the age of 12 or 13 months each gave birth to an offspring. Either case is an unusual occurrence. However, the latter condition has been reported in New York (Cheatum and Morton, 1942). As not more than 6 groups of triplets were observed during this early period, and many single fawns were noted each summer, it is circumstantial evidence that such a high rate of increase was maintained only by some of the fawns becoming pregnant in the fall, and dropping an offspring the following spring or early summer."

Seton (1929: 258), whose remarks on fecundity were quotations from Rodes (cited from Lantz, 1910) and Shiras, which I have cited above, stated that he had never heard of anyone seeing a doe actually accompanied by four fawns or even three. This he wrote after quoting Audubon and Bachman (1849: 226) that two was the average litter in Carolina [*O. v. virginianus* (Boddaert)] and that triplets were nearly as common as singles there.

At this point perhaps it is of interest to mention reports of quadruplets. Audubon and Bachman (*ibid.*) reported four fetuses from a doe killed at Goose Creek, near Charleston, South Carolina. A 1949 news release from the Michigan Department of Conservation, datelined Traverse City, April, reported the finding of a dead doe with four "well developed" fetuses. In a letter of January 19, 1950, I. H. Bartlett of that department stated that perhaps an average of one such case per year is reported in Michigan, that generally one fetus is much smaller than the others and would die at birth or soon after, and that there are reports of four fawns seen with a doe. On April 26, 1949, a doe was killed by an auto at Chautauqua, New York; autopsy revealed 'four fully developed fawns in perfect condition" (Hyde, 1949). A check on this report reveals that two fetuses

were about the same size, a third was slightly smaller, and a fourth slightly larger than these two. They were normal in appearance and probably at least 120 days along in gestation, as all were in spotted pelage (C. W. Severinghaus, personal communication).

The phenomenon previously mentioned of yearling deer fawning is not new to the literature. 'W. E.' (1831: 397) of Roanoke [? now Roanoke Rapids], North Carolina, wrote in regard to the deer in his park: "I have known but one doe to have fawns before she was two years old." A. N. Cheney (1896*a* and 1896*b*) reported that a captive doe, born in 1895, gave birth to a single fawn in 1896. This was at Loon Lake in the Adirondacks. The next reports also were from New York State: Cheatum and Morton (1942*b*) and Morton and Cheatum (1946). Also, a 121-pound doe aged between 12 and 13 months, killed by an auto on May 16, 1949, at Bethlehem, New York, had shed three corpora lutea and contained a doe and two buck fetuses; the pin bone to forehead measurements of these were: doe, 241 mm., bucks 215 and 241 (C. W. Severinghaus, personal communication).

"Deer are very prolific: I have never owned but two does that had less than two fawns at a birth. A friend of mine owned a doe that had three fawns, three years in succession, and they were all females" (W. E., 1831: 397).

Diana, with at least six sets of twins and five of triplets, has produced an average known litter of 2+ for 14 reproductive years; a third of her litters have been triplets. In New York State, Morton and Cheatum (1946: 245) examined 211 reproductive tracts from adult does containing fetuses and reported as follows: 102 singles, 98 twins and 11 triplets. The ratio in those from the northern region of the state (where the diet is less adequate) was 8:2:1; from southern New York, 3:6:1 (*ibid.*, 244). The same authors reported 37 pregnancies in 102 doe fawns from the southern region of New York; of these, 35 were singles and 2 were twin fetuses.

The Harris Brothers, taxidermists at La Feria, Texas, have an 8½-year-old doe whitetail [? *O. v. texanus* (Mearns)] named Minnie. Through 1949 she had fawns seven times for a total of 14. She had twins each year, except triplets in 1947 and a single fawn in 1948 (M. H. Whisenhunt, Jr., personal communication, Jan., 1950).

In *Life* magazine (vol. 14, no. 19, page 98, May 10, 1943) appeared an item on "Doe's Triplets," with an excellent photograph of a whitetail and her three nursing fawns. According to the text, a year-old doe [? *O. v. texanus* (Mearns)] near Kerrville, Texas, gave birth to triplets and this became an annual event, she having produced her fourth litter of triplets when barely five years of age. In a letter of January 26, 1950, Mrs. W. H. Ramsey wrote me as follows regarding this doe. It was tame, having been hand reared from about three days of age, and was not penned except for about two weeks at fawning time. At 13 months it had a doe fawn (not triplets as reported in *Life*); at 1 year 11 months it had doe triplets weighing 3 lbs. 7 oz., 3 lbs. 6 oz., and 3 lbs. 3 oz., the smallest dying at three days of age; at 2 years and 11 months she had 2 does and 1 buck fawn; at 3 years and 11 months she had doe triplets; and at 4 years and 10½ months she

had 2 bucks and 1 doe. She then was taken to Bear Creek Ranch. Mr. R. H. Friedrich of Bear Creek Ranch, Hunt, Texas, wrote me on January 25, 1950: "The following year after we placed the doe in the game preserve she had triplets again, but since that time we have lost all trace of the doe." In an 800-acre preserve she reverted to the wild state.

DeGarmo *et al.* (1949: 61) recently reported a doe [*O. v. virginianus* Boddaert] in West Virginia, taken as a yearling in 1936. From 1936 through 1946 she produced and raised twins each year; she had singles in 1947 and 1948 and twins in 1949. Her known total is 26 fawns.

A mule deer that allegedly had twins yearly for 20 years will be mentioned later in this paper.

Notes on antlers.—Elmer and another yearling born in 1943 and raised at the state game farm at Gray, Maine, were brought to Tomhegan in 1944. The other yearling, a spikehorn and tamer than Elmer, was driven out of camp by Diana within 24 hours and never was seen there again. Elmer remained, in spite of Diana's attempts to get rid of him. He had four points in 1945 and eight in 1947 and 1948. Mike, born to Diana on June 11, 1945, had nine points in 1948. Among Diana's other progeny, Hale and Hearty, when yearlings in 1943, each had five points. Diana's first fawn, Pan, Jr., had six points his second year.

In the fall of 1948 Elmer was observed rubbing his antlers most gingerly, just above the burr region, on the edge of a small stump. This experiment appeared to be painful and he soon quit. About a week earlier Mike had shed his velvet, taking about three days to get rid of all of it. Elmer finally shed his velvet in one night in not over six or eight hours. He came to the kitchen door early the next morning with bloody antlers, but not a shred of velvet remaining. Mr. Cram found the velvet, practically entire, of one antler snagged on the end of a branch which was part of a brush pile stacked for burning. Especially when the time approached to shed velvet, both Billy and Elmer seemingly enjoyed knocking over Mr. Cram's wheelbarrow piled with twigs, knocking about and scattering brush piles and even scattering piled logs that weighed up to about a hundred pounds each.

About January, 1948, Elmer shed an antler in front of the camp's winter cabin when several persons were present; a few days later the other fell off. The few observations indicate that the deer pay no attention to shed antlers.

Food and feeding habits.—As for handouts, the nearest approximation to a feeding schedule is breakfast, dinner, and supper at the kitchen door. Occasionally kitchen scraps are tossed out at any time of day. When there are many guests in camp, they feed a variety of sweets and other items at almost any time that deer come around. The deer may come to the kitchen door for handouts, singly or in groups, at any time of day or night. They are fed vegetable tops, stale bread, potato peelings, cake—in fact, all kinds of scraps—and up to 1946, when the camp had two cows, quantities of milk the year round. Of course they eat a good deal of wild food in addition to these handouts and are fond of the salt licks that are provided for them.

Supplemental feeding in winter is the same as in summer, with the following

additions. A small unmeasured amount of oats is poured into one pan for them at meal times. When the snow is deep, boughs, mostly of balsam firs, sometimes are cut and left on the snow for them to feed on. When the year's supply of wood is being cut in winter, the deer come running at the sound of a tree falling and eat the lichens (*Usnea*) that grow on the tree trunks and limbs. A sample of 'cedar moss,' *U. longissima* Ach., and of 'birch moss,' *U. cavernosa* Tuck., from the camp area were submitted to Dr. G. A. Llano of the Division of Cryptogams, U. S. National Museum, who identified them. The deer also have been observed to stand on their hind legs to reach this lichen on standing trees. The herd yards back of the winter cabin.

The deer show no particular liking for the plentiful supply of grass that grows on the camp grounds. They are fond of the little puffballs (Lycoperdaceae) that grow on old stumps in the fall. They also are fond of beechnuts (*Fagus grandifolia*), boughs of white cedar (*Thuja occidentalis*), and hemlock (*Tsuga canadensis*), and some lichens and mosses. The *Usnea* previously mentioned is a year-round food and evidently contains something that the deer particularly desire. Broad-leaved plantains, *Plantago major*, are much sought on the camp grounds and are eaten very selectively. I observed that a buck fawn, Flag, at the age of about 50 days, ate these plantains with seeming relish, also dandelions, *Taraxacum officinale*.

According to Mr. Cram, fawns from about their fourth day on eat a small amount of grass and other ground herbage.

It is of interest that Mr. Cram very rarely saw deer, when about camp, stand on their hind legs to reach food. He often tried to get the tamest deer—Billy, Elmer, and Diana—to do this by holding up sweet food, with no success.

In the summer months Billy and Elmer showed a particular fondness for young red maple, *Acer rubrum*. These bucks followed Mr. Cram when he was clearing trails and, having paid no attention to standing maple sprouts, they ate them with seeming relish once he had cut and tossed them aside. They even smelled twigs without leaves that he had picked and thrown off the trail into the bushes. Mr. Cram stated: "I have frequently noticed, especially with maples, that when a tree is cut down or a limb sawed off and left lying on the ground it will attract all deer almost immediately, and they will begin eating the leaves—though they let go untouched the leaves on growing trees of the same species that are within their reach."

Both Billy and Elmer had a fondness for tobacco, but none of the does have liked it. These two bucks were born elsewhere, reared in captivity, and probably developed the tobacco fondness before coming to Tomhegan. In past years few of Diana's fawns took food out of a person's hand. She reared her fawns to be shy of humans and it is only in late years, since she has aged and become less 'bossy,' that some of the fawns have begun to accept food from the hands of guests.

No vegetables are grown at Tomhegan Camps; it is hopeless to try to raise anything, even potted plants on cabin porches. The soil is poor and the animals get at everything. Cows did the most damage, then deer, woodchucks, and snowshoe hares. Chipmunks and red squirrels dig up almost anything planted.

In July, 1949, I investigated the food conditions in the woodland about Tomhegan Camps and was in no way surprised to find that it had been browsed heavily in the summer months of 1947. All striped maple, *Acer pennsylvanicum*, red maple, and beech shoots had been browsed at that time, also considerable balsam fir at about that time. There are no low limbs on cedars near camp. There had been a good growth, especially of maple and beech shoots, in the two succeeding summers, indicating no food shortage then. There were no young trees of the species just mentioned in age classes between two years and fair-sized saplings with high limbs. I learned subsequently that the Tomhegan Camps deer herd reached its maximum size—15 animals—after the fawning season of 1947.

In summer the deer drink very rarely when in sight; almost certainly they drink more often at night. Marjorie Spinney commented that she never had noticed them drinking in summer, but that in winter she gave them water and they drank very little.

Individuality.—Billy was the tamest deer that the camp ever had, although unsafe to be near during the rut. Elmer, the next tamest, was gentle, showed a fondness for children and even during the rut was well behaved toward humans. During her first year Diana was very tame and followed Marjorie around like a dog. She always has shown a marked preference for women. She has been 'jealous,' however, even when the bucks were petted by camp guides. It is of interest that Billy and Elmer, both born in captivity, never seemed to have as much springiness and bounce in their gaits as Diana's fawns.

Billy would walk up to a sitting person and lick the person's neck; Elmer did this less frequently. The way they would approach a person and touch the bare skin with the tip of their tongue seemed to indicate a liking for human companionship. Both Billy and Elmer would walk to where Mr. Cram was spending the afternoon more or less in one spot, sawing logs or splitting wood, and stay about for hours, often getting so close to the swinging axe that it was necessary to interrupt operations and drive the deer away. Diana and her offspring never showed the same degree of interest in human companionship.

For two years Elmer's close associate was a white domestic rabbit, Pinkey. Elmer did not travel much with Diana and her family because she chased him away so often. He took up with Pinkey who was left alone after all other domestic rabbits were removed. The deer and the rabbit were together a great deal, day and night. Often when Elmer laid down Pinkey would run over to him and snuggle up; then a thorough tongue bath was in order, each licking the other at the same time.

On June 22, 1949, wardens brought to Tomhegan Camps a buck fawn, Flag, believed to have been born the first week in June. All the camp deer showed an aversion toward him from the very beginning. He was very tame. Often he tried to join Diana and her family, but she would not allow it. On July 10 he was found with a compound fracture of the left foreleg, probably from being kicked by some deer with which he attempted to associate. On July 22 he was just beginning to regain some use of his leg, which was in a splint; by mid-September the splint had been off for weeks and his limp was hardly noticeable. A gradual toleration of him developed among the other deer. By November he had won full accept-

ance and Diana treated him as a member of her own family, giving him the same thorough tongue baths as her own offspring.

Miscellaneous behavior notes.—For several weeks after they are born, and the younger the more often, the does lick their fawns more generally, including the anus. This licking is done very vigorously, to the point of lifting the fawn partly off the ground.

The young fawns do not always seek shade; in fact, they often prefer to lie in the sun. The frosts still are quite severe at night in early June at Tomhegan when young deer are about.

The deer often are seen lying down and quietly chewing their cuds; they defecate on arising as cows do.

Mr. Cram never saw any of the Tomhegan deer swim. When Billy first was brought to camp he went down to the dock, jumped off and started swimming toward Farm Island, three quarters of a mile away. He swam so rapidly that two persons paddling a canoe had difficulty in overtaking and heading him back to camp.

The camp deer often are nervous and restless on windy days.

In 1946 it was noticed that Diana's right hind hoof had begun to curl at the tip, causing a slight limp. July 31, a dark night, three men undertook to trim this hoof. Marjorie Spinney enticed Diana into the garage, which was lighted by a single electric light bulb. All went well until hands were laid on Diana when, at one bound, she cleared a 31-inch-high work bench littered with oil cans and tools, crashed through a pane of glass and, avoiding a thick clump of striped maple growing just outside and almost in line with the center of the window, she landed unscratched after a 56-inch drop to the ground. The window aperture was $19\frac{3}{4}$ inches high by $11\frac{5}{8}$ inches wide. Diana was 12 years old that June.

Shedding hair.—In June when the deer start to shed their winter coat the does lick the hair off the fawns and the latter reciprocate with the mother and/or litter mates or those of the previous litter. The fact that the head and neck are free of old hair first apparently is because of mutual licking rather than a pattern of shedding. Diana is fatter and in better condition than the other deer (she monopolizes the best food) and starts shedding a few days earlier than the others. In fall she starts growing her winter pelage a little earlier also. Pelage change is under hormonal control and phases of the endocrine cycle probably come somewhat earlier in a deer in prime condition.

In 1949 the older Tomhegan deer lost their red coats and the fawns, except Flag, their spots about the first of September. Flag still had a few faint white traces on his flanks the third week in September. A history of artificial feeding, recuperation from a broken leg, and no grooming over a long period may have caused the delay in his molt.

Adult mortality.—Pan was illegally shot as a yearling about a mile from camp. In 1938 Billy, being very unwary, walked up to a hunter and was shot some four miles overland from camp. After the 1947 hunting season two deer failed to appear in camp and are presumed to have been shot. The herd numbered 12 at the start of the 1948 hunting season. After the season ended six deer were

missing: Elmer, Mike, Judy and her fawn, and Jane and her fawn. This was the greatest loss of any year and, judging from deer behavior at camp, it is likely that all were shot or they would have returned after the rut.

Discussion.—A whitetail doe in Maine, given adequate food and relative freedom from predators, has produced more fawns for more years than usually make up the life span of the northern whitetail deer. Maximum ages reported for deer of the Genus *Odocoileus*, by Severinghaus (1949*b:* 212–213), are for captive and semi-captive individuals as follows: a Florida deer, *O. virginianus* subsp., 15 years; a buck coast deer, *O. hemionus columbianus* (Richardson), 16 years; and a doe Northern whitetail deer in Allegany State Park, New York, at least 16 years. He overlooked the report by Ross (1934) of an earmarked unconfined doe *O. h. hemionus* in Fresno County, California, that had "twin fawns yearly for twenty years" and was barren in her last year. On June 8, 1932, when she was a day-old fawn, a doe northern whitetail deer was placed in captivity at Putney, Vermont. Being isolated in captivity she has had no fawns. At the age of 17 years and 8 months she "appears to be in good condition, is active and looks good" (Roger Seamans, *in litt.*, Feb. 21, 1950).

Severinghaus (1949*b:* 213) stated that the records he listed "indicated that individual deer could live to be 14 to 16 years of age, possibly older. Nevertheless, all of these deer of extreme old age either had been held in captivity where foods other than normal browse diet were provided or they were provided with foods which were softer and possibly more nutritious."

Referring again to Severinghaus (1949*b*), the teeth in deer wear down as age increases. It follows that the lower jaw is in a progressively differing relative position to the upper as a deer ages. When slightly over 15 years old, the shape of Diana's head, also the deep preorbital groove or pit, clearly indicates her advanced age (Plate I). Mrs. Spinney is most emphatic that Diana has slowed down in eating, even oats; the doe even cannot chew apples as well as formerly.

No doe at Tomhegan is known to have fawned as a yearling, although a fair percentage of New York State yearlings produce fawns. It is possible that a history of a certain amount of hand rearing may in some way inhibit early breeding. "Our experimental herd at Delmar, New York, has yielded no record of a fawn breeding. We are more inclined to believe that the diets of hand-reared deer are deficient in some as yet unknown aspect and that sexual development is somewhat retarded as a consequence" (E. L. Cheatum, personal communication).

With one exception, the earliest known fawning date of any deer at camp was May 24, the latest June 11. Of 42 fawns in the period 1936–1949, thirteen were born in May and 29 in June. The exception was Harriet who, as a two-year-old, gave birth to a single fawn on May 21, 1942. As a rule, Tomhegan does having their first fawns give birth to them about a week later than Diana. In New York State Cheatum and Morton (1946: 256) noted that breeding dates of fawns "were somewhat later than for adults." A normal gestation period would, therefore, result in somewhat later births. The first estrus in fall in two-year-old Tomhegan does evidently occurs later than in older deer; if it were nearly simul-

taneous in all age classes, but two-year-olds were not bred until a recurrence of estrus after about 28 days, their fawns would be born four weeks (instead of one) later than those of older does. It is of interest that Wislocki (1943: diagram opp. p. 632) postulates a somewhat later onset of spermatogenesis in younger northern whitetail deer. It appears probable that younger deer of both sexes come into reproductive condition later than older ones.

Triplets first were noted when Diana was six years old and high fecundity has been maintained in subsequent years. It is rather improbable that comparable records of total fawn production will be obtained very often from other individuals of this race. The Texas doe that had triplets beginning with her

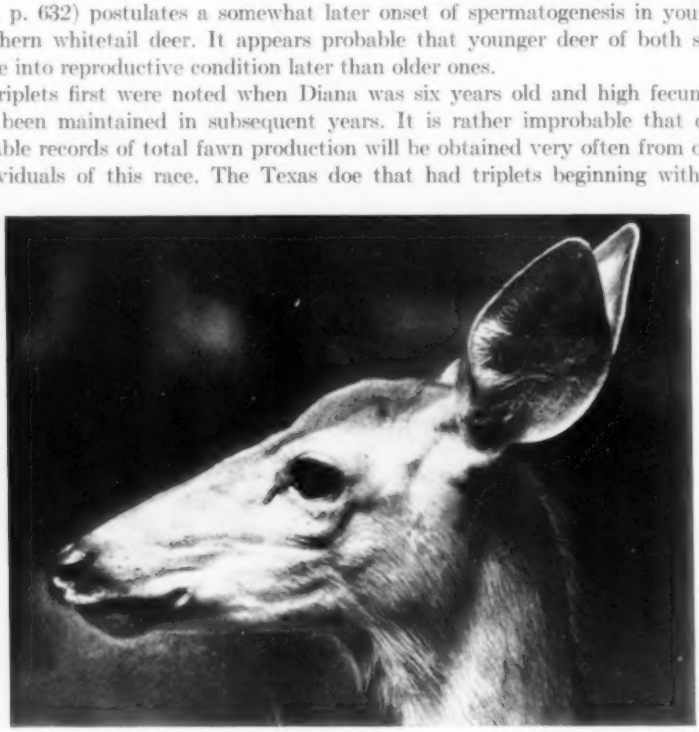

PLATE I

Diana, slightly over 15 years of age, showing facial characters of a very old doe. July 23, 1949

second litter, also a number of unverified reports for other southern does, indicates occasional high fecundity in early life in tame deer, hence a likelihood that records of total fawn production per doe surpassing Diana's now are in the making. Probably triplets are not rare on good deer range in Maine, but for three to survive may be rare. The mother cannot defend three very well, also she may lack an adequate supply of milk for them.

Deer are very selective feeders, keeping on the move within their home range and choosing such items as appeal to them, except, of course, where an overbrowsed range limits their choice. Being thus highly selective, they are very responsive to supplemental feeding of items they prefer. Their selectivity makes for optimum diet on good range, hence good condition of the herd, hence

fecundity. Some eating traits of the Tomhegan herd, however, are hard to understand, such as that of coming on the run to eat leaves off cut maple limbs and bypassing seemingly identical fodder that they can glean readily without human aid. Also, they will stand on their hind legs to reach lichens in the woods, but will not stand up for sweets in a person's hand.

Pen-reared fawns definitely develop certain traits from such conditioning. In the Tomhegan herd hand-reared deer that have been released there show such obvious characteristics as being more companionable toward humans (even lack of aggressiveness during the rut in the case of one buck) and less springiness of gait than in wild-reared deer.

Leadership in the Tomhegan herd is a rigid matriarchy, Diana monopolizing the best food, controlling which deer shall be driven from camp, and whether those remaining shall associate with her and her younger offspring. Her leadership is recognized by all the deer; she asserts it by kicking or by striking with her forefeet.

Deer that are on friendly terms maintain their mutual relationship at least in part by licking each other with their tongues.

The Tomhegan herd, especially the bucks that wander more than the does, presumably suffers depletion mainly from shooting losses.

Acknowledgments.—The writer first learned of the Tomhegan deer herd from Miss Barbara Lawrence of the Museum of Comparative Zoology at Harvard. Special thanks are due the late Harward W. Cram for allowing access to his notes and photographs and for answering many questions and aiding in the preparation of this paper. The Spinneys provided data. E. L. Cheatum, formerly of the New York State Conservation Department, kindly read the manuscript and made suggestions for its improvement.

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New York State Museum, Albany. Received November 13, 1950.

NOTES ON THE ECOLOGY OF WEASELS IN GUNNISON COUNTY, COLORADO

By Horace F. Quick

Weasels are the most widely distributed mammalian predators on the North American continent. Because of their numbers and their habits they must exert a great control on small mammal populations. Initial attempts to find a method of appraising this influence were begun before 1942, but were interrupted. The following report is on the beginning made in 1941, and subsequent studies through 1946.

At opportune times during the years 1941 to 1946, observations of the habits of weasels in Gunnison County, Colorado, were made. This county lies on the Western Slope of the Rocky Mountains. It is range land of about 4000 square miles, and contains much high mountain country. Very little of it is below 7500 feet in elevation. The county has within its bounds five of the life zones (Carey, N. Amer. Fauna, no. 2, 1917) commonly found in the western part of the United States. These range from the highest, the Arctic-Alpine, down through the Upper Sonoran. The most extensive zone is the Transition, indicators of which, in this county, are the sage brush and aspen types, with sparsely scattered Douglas fir and ponderosa pine.

The entire county and all of the life zones within it are ranged by the long-tailed weasel, *Mustela frenata nevadensis* (Warren, The Mammals of Colorado, 1945). This weasel was collected and observed numerous times during the period from which this report is made. Warren also lists the short-tailed weasel, *Mustela erminea lepta*, as occurring in this region, but it was never encountered by the writer.

At the beginning of the work the plan was drafted in two parts. One was to try to determine the food requirements of weasels, and to obtain a means of evaluating quantitatively the contents of droppings found in the wild. This was to be done with caged weasels under control and observation. The second part of the plan was to search for a method of calculating weasel populations. While doing this, scats were collected as a means of determining what prey species wild weasels selected. The work was begun in July, 1941. Captive animals were kept prior to the war period, but only the occasional collection of droppings and field observations was continued through the war years. This report is mainly on food habits as determined by scat analysis and field observations indicating some ecological relationships of weasels.

Field reconnaissance of the county proved the presence of three similar mustelids, the weasel, the mink, and the marten. Since the general habits of these animals are similar, it was necessary to ascertain means of distinguishing their tracks and trails.

The tracks of weasels were observed in almost constant density from the foothills at elevations of about 7500 feet upward. Much weasel sign has been observed above timber-line at all seasons of the year. Their tracks are particularly noticeable on the snow of the open ranges of the Transition Zone and the Alpine Zone to elevations well above 12,000 feet.

Thus, the weasel is found in association with marten in the Canadian, Hudsonian, and Alpine zones, and with the mink in the Canadian, Transition, and Upper Sonoran zones along water courses. It is also found over the more extensive dry parts of the Transition and Upper Sonoran zones, which are to a greater extent not inhabited by mink or marten. These three mustelids compete, to a degree at least, for range and prey. The adaptability of the weasel, as a species, to such diverse and extensive environmental conditions brings it into association with a large fauna vulnerable to it as prey.

The relative abundance of prey species.—A food habits study is of limited practical application unless the abundance of prey species is known. Actual quantitative methods of appraising prey populations were desired, but not wholly accomplished. Notes made on field checks following rodent control operations, trapping, and general observations were used to inventory the prey species of the fauna and from them some relative abundance appraisals were postulated.

These data show that two species of mice, *Peromyscus maniculatus rufinus* and *Microtus longicauda mordax*, are the most abundant mammals available as prey for the weasel. Further, both of these forms are found in suitable habitat niches in all of the life zones occurring in Gunnison County. They are therefore in association with the weasel throughout the zonal range common to all three mammals. The other mice which range here are not as widely distributed zonally, nor as abundant. No specimens of *Phenacomys* or *Zapus* were obtained in Gunnison County. However, the remains of a *Zapus* were encountered in one weasel scat indicating at least temporary representation of that species in the Gunnison County fauna. Woodrats were observed in all zones, but are not as abundant as the *Peromyscus* and *Microtus*. Pikas, snowshoe hares, and cottontails were found in their respective life zones. During 1941 and 1942 cottontails were very abundant, but noticeably scarce in 1944–1945.

In trying to determine population values of these forms the extent of their habitat in this district and their territorial requirements as would affect the relative abundance of each species was considered. Averages, based on notes for the five-year period, are given. The following is a list of mammals, with relative abundance noted, which are resident in the fauna of Gunnison County (Warren, *loc. cit.*), and which are liable to weasel predation.

Masked shrew, *Sorex cinereus cinereus* ..... scarce.
Dusky shrew, *Sorex obscurus obscurus* ..... scarce.
Water shrew, *Sorex navigator* ..... rare.
Bats, *Vespertilionidae* ..... common.
Golden mantled ground squirrel, *Citellus lateralis lateralis* .... common.
Prairie dog, *Cynomys gunnisoni gunnisoni* ..... abundant.
Least chipmunk, *Eutamias minimus consobrinus* ..... abundant.
Colorado chipmunk, *Eutamias quadrivittatus quadrivittatus* and *hopiensis* ..... abundant.
Spruce squirrel, *Sciurus fremonti fremonti* ..... abundant.
Mountain gopher, *Thomomys talpoides fossor* ..... very abundant.
Bushy-tailed woodrat, *Neotoma cinerea orolestes* ..... abundant.

Deer mouse, *Peromyscus maniculatus rufinus*.....very abundant.
Phenacomys, *Phenacomys intermedius intermedius*.....rare.
Mountain vole, *Microtus montanus fusus*.....common.
Long-tailed vole, *Microtus mordax*.....abundant.
House mouse, *Mus musculus*.....rare.
Jumping mouse, *Zapus princeps princeps*.....rare.
Pika, *Ochotona princeps figginsi*.....abundant.
Snowshoe hare, *Lepus americanus bairdi*.....common.
Mountain cottontail, *Sylvilagus nuttalli pinetis*.....common.

This list might also include the following larger mammals which inhabit Gunnison County, but do not seem likely to be vulnerable as weasel prey because of their size.

Yellow-bellied marmot, *Marmota flaviventris luteola*.....abundant
White-tailed jack rabbit, *Lepus townsendi townsendi*.....abundant
Muskrat, *Ondatra zibethica osoyoosensis*.....abundant

Many species of birds indigenous to the district might also be prey for weasels. Indeed, the weasels' diet is not restricted to the small mammals listed. In other studies of weasel food habits, birds were found to form but a small portion of the diet, but their remains were difficult to identify. The list of resident birds vulnerable as prey to the weasel is so large that it is not included here.

Experimental feeding of weasels showed that they will kill and eat reptiles, amphibians, and insects, and that they will eat fish. Therefore, any forms in these categories which are indigenous to the region could be expected to occur in the diets of weasels.

The collection of scat samples.—Droppings were collected during all seasons of the year and from all of the life zones found in Gunnison County. Each specimen was labeled showing date and locality of collection and an approximation of its freshness with regard for the seasonal feeding period it represented. Specimens found on the snow, for example, could readily be dated within a few days, but specimens collected during the summer were more difficult to date. Usually, scats were found singly on rocks in trails. Occasionally several would be found on the same rock, and their character generally indicated different dates of deposition. This suggests frequent use of the same habitat or "favorite routes" by the animals. A few dens were located and always these yielded a number of droppings found in a "latrine." Before analysis, physical measurements of weasel scats were made to aid in identifying them from scats of other mustelids resident in the district. The measurements obtained were oven-dry weight, maximum length, and maximum diameter. Scats were then soaked and disintegrated separately in a watch glass. The bone fragments and teeth were picked out and several swatches of hair arranged on a slide in water for microscopic study. Casts of the unknown need not be made, usually, unless it is not possible to identify the specimen on medullary characteristics, color pattern, diameter, and length. Sometimes hair and feathers are so dirt- and grease-coated that they must be cleansed

before these characteristics can be seen. Agitation in warm soapy water was found suitable for preparing the specimen for examination.

Food habits of weasels.—A study of the food habits of an animal is probably the best approach to an understanding of its ecology for it also leads to an investigation of its relationship with factors in its environment. This study of weasel food habits has indicated some of these relationships, a discussion of which follows. The vole is the most frequently selected prey, perhaps because of its ubiquity, and deer mice appear often as items in the diets of weasels. The latter species is probably just as abundant as the vole, but by virtue of its saltatorial habit may be more capable of escape. The third most frequent item was the chipmunk. It was not as abundant numerically as the voles and mice though it was, relatively, very abundant. Its habit of hibernation probably results in seasonal removal from the list of prey, further reducing the frequency with which it might be expected to occur in the weasel diet. Another factor which might affect the frequency with which a prey species occurs in the diet of a predator is its body size, and the proportional energy it yields in the form of food. Similarly, the energy required of a predator to overcome prey has a bearing upon the frequency with which prey appear on the predatory menu. This ratio of energy in-put to out-put probably is of significance in the ecology of predation.

Cottontails are generally too alert and too fast for weasels, but may on occasion fall victim to their attacks. In a cage experiment it took a weasel seven minutes of fierce attack to conquer a healthy young cottontail. Had the cottontail been in the freedom of the wild it is doubtful if the weasel could have overcome it. Cottontails and prairie dogs appeared but twice each in the tabulation of the analyses, but woodrat remains were found somewhat more frequently. Evidence of predation on cottontails in winter has been seen when tracking is easy. Weasels have been seen in pursuit of woodrats, pikas, and golden-mantled ground squirrels. The diet analysis does not indicate that the weasel is more than moderately successful in the hunting of these prey animals. One notable observation was witnessed in January when a weasel in white winter coat pursued a woodrat for a period of about ten minutes. The event took place at midday on the rimrock of a small canyon in the Transition Zone. The rat seemed to be working an old ruse by which it escaped the weasel, at least temporarily. Three times it climbed clinging upside down to the underside of a projecting rock ledge and three times the weasel followed, but was not able to go more than half the distance to the rat when it would lose its grip and fall six or eight feet to the ledge beneath. At this opportunity the rat would retreat from its precarious haven to the rimrock whereupon the weasel would encounter it again. After a brief chase through the rocks the ledge retreat was sought again and the weasel tried and fell again. Following the third performance both animals disappeared in the rocks, the finale unknown to the observers.

About five per cent of the scats contained pocket gopher remains. Gophers are probably difficult prey for weasels to catch. Being able to throw up "road blocks" behind themselves when pursued underground they are likely killed only when taken offguard at or near the surface.

No traces of spruce squirrels were found in the scats collected in Colorado, but one scat found in Wyoming suggested that the weasel may prey upon them at times. The golden-mantled ground squirrel, which is almost as large as the spruce squirrel, appeared in about two per cent of the droppings. It would seem that this medium-sized rodent would fall prey to the weasel more frequently than this study indicates. The fact that it is available in goodly numbers in all of the life zones may not, however, offset the period of its temporary removal from the prey list when it is in hibernation. It must also be considered that even though its relative abundance is as great as some other prey species its numerical abundance is less. Therefore, it should not be expected to occur in the diet of predators as frequently as some other items of prey. Jumping mouse remains were found in only one scat. This fast moving species does not likely fall prey to weasels very often. Its scarcity would also reduce the frequency of its vulnerability as a species. The remains of a bat found in one dropping must certainly indicate an oddity in the weasel diet. Yet it is conceivable that bats are vulnerable prey when dormant or when sleeping in rock crevices. There is the possibility, of course, that it was found dead and eaten as carrion.

The most striking evidence of avian prey was the occurrence of the remains of a female teal, *Querquedula*, in a scat. As this scat was found in fresh condition, in late summer, it may be that the bird was caught while incapable of flight during the moult. Including this incident, only about five per cent contained evidence of birds as food items in the weasel diet. The only identified remains were those of the teal and the foot and tarsus of a brown creeper, *Certhia*.

A notable quantity of insect remains was found in an analysis of the droppings. The occurrence of grasshoppers, Tettigoniidae, in the diet is not surprising as they are abundant in summer and large enough to make attractive prey for the weasel. Paper wasps, *Vespula maculata*, in adult form, occurred in about nine per cent of the scats, raising the question of how they were captured without injury to the predator. It may be that these were eaten while in a dormant stage. The larvae of this species were found also in a few scats and moth larvae were found in one.

Odd items of food in the insect category consisted of some larvae of Trichoptera, an adult fly, Tabanidae, and a flea. A few scats contained insect parts which were not identified. About 15 per cent of the scats examined contained insects, but these also contained other items of food which formed a more substantial part of the diet. It appears that the weasel does not depend upon insects as a staple food, nor as an emergency food, for they are largely available only in summer when other forms of food are usually abundant.

Altogether, 23 scats contained vegetable matter. One of these was a mass of vegetable fiber which suggested that at times weasels may eat vegetation, perhaps for the same reasons that domestic dogs do. Each of five droppings contained about 25 per cent *Ribes* seeds and three contained *Vaccinium* seeds and the skins of berries. The bulk of the vegetable debris found in weasel scats may be the result of their habit of eating the entire bodies of small mammals and birds, including the contents of their stomachs. The remains of the berries of

Ribes and *Vaccinium* probably indicate direct consumption of such fruits when available. Later observations have shown that marten, too, eat quantities of berries and that some trappers, being aware of this, use a "jam" of blueberries and vegetable oils for marten baits.

A few prey species are confined to certain life zone limits. This has a tendency to reduce the frequency with which one might expect their remains to occur in a gross analysis of weasel scats collected from all life zones. The cottontail is rare above the Transition Zone. The snowshoe hare is rare below the Canadian Zone. Spruce squirrels are generally confined to the timbered zones where pine, spruce, and fir forests afford them forage. Pikas range the upper zones rarely below the Hudsonian.

TABLE 1.—*Frequency of food items occurring in weasel scats*[1] *listed by location of collection*

LIFE ZONE	NUMBER OF SCATS	ITEM								
		Microtus	*Peromyscus*	*Eutamias*	*Cynomys*	*Thomomys*	*Citellus*	*Ochotona*	*Vespula*[2]	Tettigoniidae
Upper Sonoran	15	6	7	2	0	0	0	0	0	2
Transition	22	12	5	1	2	1	2	0	0	0
Canadian	18	11	1	2	0	1	0	0	3	0
Hudsonian	11	7	1	4	0	1	0	0	0	0
Arctic-Alpine	11	4	1	5	0	0	0	1	2	0
Total	77	40	15	14	2	3	2	1	5	2
Per cent occurrence in 77 Scats		52	19.5	18.2	2.6	3.9	2.6	1.3	6.5	2.6

[1] Only outstanding items are listed to conserve tabular space. Minor items are mentioned in the text. Mr. Charles C. Sperry, U. S. Fish and Wildlife Service, identified numerous difficult items.

[2] Insect remains were identified in part by Dr. L. Jones, Colorado A & M College, Fort Collins, Colorado.

Thus, the forms of prey which are associated with the weasel in all of the life zones, and which are in yearlong contact with them, are likely to appear more frequently in the dietary selection. Those which the weasel as a species encounters in only a few of the life zones, and/or which are temporarily removed from the prey list by hibernation, are not apt to occur as often in the diet. The accompanying list (Table 1) indicates a grouping of scats according to the life zones in which they were found. The proportional sizes of these scat groups are quite comparable to the proportional areas of the life zones in which each of the groups was found. Most of the scats were found in the Transition Zone, the life zone with largest area in this district. Dens found in the Upper Sonoran Zone yielded large numbers of scats which tended to distort the scat-life zone-area ratio. The Upper Sonoran Zone is the smallest in area of the five found in Gunnison County.

Since the scats were collected at random, the ratios suggest that the weasel population was uniformly distributed through all life zones. From other studies

the weasel has been shown to have a small home range and a short cruising radius. The first three items of diet listed in Table 1 were found to have occurred in scats found in all life zones. The place of collection of the scats containing these animal remains fitted with their characteristic habitat zones in life. It would not be expected that a species of short cruising radius like the weasel would wander far between making a kill and defecating the remains. Similarly, one should not expect to find traces of prey strictly from one zone occurring in a scat found deep within a different zone. These observations were of some aid in identifying remains found in scats. The likely occurrence of border line cases, however, makes caution imperative.

The short cruising radius of the weasel, and the zonal restriction of some prey species indicates that some weasels, as individuals, would never encounter some species of prey. For example, weasels born in the broad Transition Zone would likely never range out of that zone and would never have an opportunity to hunt pikas.

The occurrence of *Eutamias* remains in scats was more frequent from the higher life zones. The reverse is evident for *Microtus* and suggested for *Peromyscus* in the data. Scats containing *Eutamias* remains probably represent summer diet, as in this zone chipmunks would be in hibernation during winter. Voles and mice are active under the snow at the highest elevations even in the dead of winter. On a number of occasions *Peromyscus* have been frightened out of subnivean runs, presumably by the vibration of skiis on the snow. *Microtus*, too, have been observed under similar conditions. Because of their presence and activity associated with evidence of weasel activity these mice must be a staple item in the winter diet of weasels. The dates of the collection of scats found in the Alpine Zone throw a little light on the subject. Two droppings found on the snow contained the remains of *Microtus*. All those containing *Eutamias* remains were found in September and probably indicate prey taken by weasels during the summer preceding. While evidence of the high altitude activities of *Peromyscus* in winter is much more abundant than that of *Microtus*, the occurrence of the latter in the winter diets of weasels is more frequent. Observations show that weasels hunt under the snow, through snow-blanketed sedge marshes, willow thickets, under windfalls, and around stumps where *Microtus* and *Peromyscus* are active all winter. About 50 per cent of the scats showed traces of *Microtus* and 20 per cent contained evidence of *Peromyscus* remains.

Hunting habits of weasels.—Observations of wild and caged weasels were pieced together to gain some idea of their hunting habits. This method of study is especially necessary with a species which is mainly nocturnal in habit. On a number of occasions weasels in pursuit of fleeing chipmunks, pikas, and woodrats have been abruptly encountered by the writer. They have been seen on the hunting lope, coursing through the favorite runways of mice, rats, and ground squirrels. Once a weasel was seen on such a search, loping slowly over the snow. It slowed its gait to a cautious walk, extended its head as if to smell or otherwise perceive its prey, and walked about 25 feet to disappear into a mouse run. The walking gait is seldom demonstrated by weasels. The wanderings of their trails

printed on the snow give, too, the idea that weasels search the favorite haunts on the lope until they surprise their prey, then there is the rush to overtake it. At straight-line speed the weasel is limited by its gait habit, but at unraveling the maze of snow tunnels or slipping through dense thickets, it is well adapted. Serpentine body form and spider-like foot work make it a successful hunter of small mammals whose flight leads a winding course. As near as the eye can detect, the weasel always has two feet on the ground, giving it a base from which to change the direction of its motion. This peculiarity of gait substitutes maneuverability for speed. It prevents the compounding of space coverage demonstrated by horses, dogs, and rabbits with their over-stride gaited gallop.

The kill.—The writer has witnessed the "kill" phase of activity only with captive animals. A large cage with a natural earth floor was used for these observations. The cage was arranged with rocks and brush and with holes in the earth floor to make as natural a setting as size would permit. Various live animals were released in the cage and observations were made on killing habits. Also an attempt was made to appraise the daily food requirements. Dead animals were offered to test the weasel's taste for cold carrion.

On one occasion a live blackbird was released into the cage. The weasel pounced on it, bit it through the wing, then killed it with a bite through the base of the skull. The weasel then began biting at the face of the bird and seemed to be eating into the brain. The beak of the bird fell free and was discarded. The weasel seemed to become sleepy, its eyes drooped. It uttered a few low chuckling sounds, walked around the dead bird several times, then laid down on it. It would get up, uneasily walk around the bird, drag it a few inches, then lie down on it again. This seemed to be the characteristic treatment dealt avian prey. Birds ranging from the size of a red-shafted flicker to an English sparrow were offered to the caged animals. The activities in each case followed a similar pattern. After the kill was made the weasel would eat a small part of the head region then curl up to sleep, having seemingly satisfied its appetite. In most cases the foreparts of the birds were eaten later. The heart and lungs and part of the breast meat would be consumed, but the entrails would be left untouched. In some cases the legs and part of the back would be eaten. Usually the primary wing feathers, the tail, feet, and tarsi would be left with most of the feathers scattered about. Kills found in the wild indicated similar activity, but generally there was evidence of more complete consumption of the prey than occurred under cage conditions.

The question of the weasels' tastes for cold-blooded prey was answered after a few cage tests. Several field observations had indicated that they had eaten parts of snakes, but the evidence did not seem conclusive. It did, however, suggest a trial, so a live water snake, *Natrix hispidon*, nearly 24 inches long, was placed in the cage. The snake seemed to try to hide its head under its coils while the weasel eagerly searched for it. The weasel seemed baffled, bit into the midsection of the snake's body and dragged it out of its coils. Then the weasel ran along the snake's body toward the tail. It seemed to sense that the snake's head was in the other direction and reversed its pursuit. By this time the snake had

writhed its coils through its own white slimy secretion. After every bite the weasel would make, it would shake its head violently as if the slime were bitter to the taste. The weasel finally located the head and killed the snake quickly with a well-placed bite. It then ate a six-inch section of the snake, leaving the belly scutes connecting the head with the remainder of the body. The weasel had been fed the previous day. At a later date, this same experiment was tried again with similar results.

To further test their appetite for cold-blooded prey, two live leopard frogs, *Rana pipiens*, were put into a cage with a weasel. The weasel would approach a frog, sniffing, to retreat shaking its head as if the frog were distasteful. After some parrying, both frogs were killed. The gourmet weasel ate only the hind legs of both frogs. In this district frogs have been seen wandering in dry sloughs where they might easily fall prey to weasels.

Mammals undoubtedly make up the bulk of the diet so a number of each species of mammalian prey was offered from day to day. On one occasion a chipmunk was put in the cage. A struggle ensued and the weasel severely injured, but did not kill, the chipmunk. A few moments later, during which time the weasel stalked around the cage, it killed the chipmunk with a bite into the skull; it then ate the eyes and brains, and the crunching of skull bones could be heard. The tip of the chipmunk's nose fell free, severed, and was not eaten. The weasel then curled up to sleep, seeming to have eaten its fill. When observed later in the afternoon, all but the tip of the chipmunk's tail had been devoured.

This incident was rather characteristic of the manner in which weasels attacked and killed other prey animals which had been put into the cage. On all occasions a struggle took place before the kill was made. Usually, following the kill, the weasel would eat a small part of the cranial region then rest awhile before continuing on the remainder of the body. Often, especially in the cases of small mammals, the entire bodies would be consumed.

Food requirements.—Experiments with caged animals appeared to be the only way of determining the quantities of food required by weasels, but the results might be jeopardized by a distorted metabolism resulting from confinement. Imposed inactivity could reduce food requirements and the loss of nervous energy resulting from restriction might work either way. Experiments with three captive weasels indicated that four mice per day for each weasel would sustain them in apparent health. Observations suggested that the weasel usually would prefer to eat a small quantity of food at frequent intervals rather than a great deal at "one sitting." Over 50 kills were witnessed and in no case did the weasels eat the entire victim immediately. In all cases mice were ultimately consumed, but at first, following the kill, only a small portion would be eaten. When larger prey was offered to the captive weasels there was a marked decrease in the number of individuals consumed. In fact, when birds the size of a blackbird were fed, they were never completely devoured.

Generally, the larger the prey the greater is the waste. Because of the inherent nature of the weasel it appears that it is natural for it to kill more than is required for immediate satiation of appetite. This may be the result of the volu-

metric ratio of size of prey to alimentary capacity of predator. Some of the weasel's habits may be traced to such relationships. For example, the cache habit may be the result of the weasel's inability to consume a "kill" immediately after its capture. The pattern of activity seems to be one of hunt, kill, eat, sleep. Since the animal quickly appeases its appetite it may either rest or even sleep after its repast or it may continue on a sortie of a recreational nature. Should it encounter prey the pattern of activity is likely to be repeated even though the animal has recently left a partly consumed prey. Such a nature would make an appraisal of the weasel's rodent control effect difficult.

Weasel populations.—Estimates of the populations of weasels in Gunnison County are made here upon reconnaissance methods. In connection with other field work the frequency of the occurrence of weasel trails upon the snow in midwinter was noted. Compared with studies of home ranges in other regions the ranges of Colorado weasels appeared to be similar. Weasel trails can usually be circumvented in a few hours in the open foothills of Gunnison County. The area encompassed can often be viewed from a vantage point, marked by the deep trail of the tracker or familiar land marks. Such areas are usually about 200 to 300 acres in area. Physiography will often govern the boundary of a weasel's home range in some manner and, therefore, exert a degree of control upon the distribution of the population.

Practically the entire area of Gunnison County is suitable for weasel habitation. There are but few habitat blanks in the form of lakes, streams, rock outcrops, and settlements. It is estimated that there are about 4000 square miles uniformly inhabited by weasels. The Public Land Survey System, upon which this estimate is based, controls area by horizontal measurement. The more irregular the surface the greater will be the surface area between comparable horizontal controls. Thus, more animal habitat is available within the county than maps show, and, therefore, population estimates are probably conservative. During the period covered by the report the density of the weasel population was calculated at two per square mile and the total population for Gunnison County at 8,000 animals.

Such a force of predators might account for the killing of more than 30,000 small mammals per day, or about 10,000,000 per year in Gunnison County. The weasel and his relatives are North America's native "mousers."

Univ. of Maine, Orono, Maine. Received August 16, 1950.

COYOTE FOOD HABITS ON A SOUTHWESTERN CATTLE RANGE

By Adolph Murie

For about a year and a half, from February, 1943, to July, 1944, I was engaged in a study of cattle losses on the San Carlos Indian Reservation in Arizona. The study required a consideration of many ecological factors such as overgrazing, malnutrition, and predation. The most abundant predator, and the one that had been considered most important as a loss factor, was the coyote (*Canis latrans*). In order to get a broader understanding of the coyote-cattle relationship, a study of the coyote's food habits was made. This was done mainly by gathering scats in the field and analyzing their contents. On the Reservation, 3981 scats were gathered; in other parts of Arizona, 84.

The Reservation consists of about 2568 square miles, practically all of which is used for cattle range. In elevation, it extends from 2500 to 6500 feet, that is, from the desert floor to the yellow pine belt. From the desert the land rises abruptly to a broad terrace at 4500 feet, from which it again rises sharply to the high range at 6500 feet. Thus the Reservation lies roughly at three elevations, each of which has its distinctive features.

The vegetation on the desert floor is characterized by much mesquite (*Prosopis juliflora*), catclaw (*Acacia greggii*), prickly pear and cholla (*Opuntia*), and creosote (*Larrea*). Rabbits and rodents appeared to be more plentiful here than at higher elevations, but had better protection from coyotes because of the brush and the abundant cactus. Only nine scats were gathered on the desert, so the study did not actually include this area.

The intermediate range at 4500 feet consists of extensive open grasslands, groves of live oak (*Quercus*) and juniper (*Juniperus pachyphloea* and *J. utahensis*), and scattered patches of prickly pear and cholla. Rabbits and rodents were not abundant, perhaps because cover was greatly reduced due to year-long, extremely close grazing by cattle. Because the cattle population was large on the intermediate range and the losses were heavy, the major part of my time was devoted to this range. It followed that the scat collections were here the largest, numbering 3216.

At the highest elevations there were extensive stands of yellow pine (*Pinus ponderosa*), live oak, and juniper (*J. pachyphloea*), and large tracts of grass lands. The prickly pear and cholla were less plentiful than at the lower elevations. Rabbits and rodents were not abundant. The range was closely grazed most of the year. On this high range 756 scats were gathered.

The outstanding characteristic of the coyote's diet at San Carlos was its high content of vegetation. About eighty per cent of the scats examined contained plant food. Juniper berry was present in 68 per cent of them, and usually composed all or a large part of those in which it was found. Prickly pear, mulberry, mesquite, catclaw, and hackberry were also eaten. Juniper was primarily a winter food; the other species were utilized chiefly in the summer and fall seasons.

FOOD ITEMS

Cattle.—Remains of Hereford cattle were found in 16 per cent of the scats. The importance of cattle in the diet depended chiefly upon the amount of carrion available. This

varied from one season to another and from year to year. On the intermediate range in the winter of 1942–43 only 154 scats or 7 per cent of 2093 scats collected contained cattle. The relatively low incidence of cattle was due in part to the fact that most of the scats were gathered among juniper groves where coyotes had come to feed on the berries. In the 116 droppings gathered away from the junipers in this period, the incidence of cattle was 34 per cent. In the winter of 1943–44 cattle remains were found in 73 per cent of the 283 scats collected and very little juniper was eaten. For the summer period, cattle was found in 26 per cent of the 840 scats gathered on the intermediate range.

On the high range cattle was of less importance in the diet. In 756 scats, which were apparently representative, since most of them were gathered along trails, the incidence of cattle was only 11 per cent.

Most of the cattle consumed was carrion, but there was some predation on calves. Among the purebred Herefords kept on good range it was known that predation was insignificant. On the overstocked ranges most types of losses were large. Although coyote predation here appeared to be light, no accurate measurement of the loss due to coyotes was possible. Some calves that were weak, too weak to follow the cows, were killed by coyotes. The subject of cattle predation will be discussed in another paper.

Peccary.—Peccary (*Pecari*) remains were found in three droppings. I have no information on peccary-coyote relationships. The agile peccary is a fierce fighter, so perhaps it may seldom be attacked by coyotes. Peccaries were seen on only three occasions. A family of young was found by a trapper in an old mine shaft. A stockman reported that peccaries had increased in recent years, and that they were reported quite abundant north of Globe.

There were a few feral domestic pigs maintaining themselves on the reservation. They occasionally were run down with dogs and roped. One stockman brought in some young of the year to raise.

Coyote.—Only one scat contained coyote remains. On February 1, 1944, a coyote was observed feeding on the carcass of an old female with much worn teeth, and three other coyotes were seen a short distance from the dead animal. The neck of the still-warm carcass was chewed and bloody, so it seemed there had been a fight, and, since this was mating time, it may have been connected with mating activities. In the same locality two days earlier a coyote was seen chasing another and biting at its side.

Rodents.—Rodent remains were found in about 10 per cent of the scats. The distribution, according to species, of the 386 occurrences of rodents is given in Table 1. The pocket gopher and the meadow vole, favorite foods in other localities, were high ranking among the rodents. The meadow vole was scarce because of the lack of cover due to overgrazing. Other rodents were no doubt similarly affected by overgrazing.

Blacktailed jackrabbit and cottontail.—The jackrabbit (*Lepus c. eremicus*) and the cottontail (*Sylvilagus*), combined, were found in 103 or about 3 per cent of the scats. The rabbits were relatively scarce, probably because of the very close grazing by cattle.

Bird.—Bird remains were found in less than 2 per cent of the scats. Wild turkey (*Meleagris g. merriami*), common in the high range, was found in three scats. The turkey remains could have been carrion because many turkeys are wounded during the hunting season. Gambel quail (*Lophortyx g. gambeli*), abundant in places, was present in nine scats. Duck remains were found in three scats. Two days after I had seen a wounded shoveller on a tank it was gone, and two fresh coyote scats that contained shoveller (*Spatula clypeata*) feathers were found on the shore. Once when a flock of ducks took wing I noted that two of them did not join the main flight, but kept circling near the pond. After a time they began to lose altitude, as though weakening, until one, and then the other, dropped to the ground. These two ducks had probably been wounded and would eventually furnish carrion.

Grasshoppers and beetles.—Grasshoppers were extensively eaten on the intermediate range from about the middle of May to the last of September. They were present in 43 per cent of the scats gathered during this period. The grasshoppers were most highly utilized during June, July, and early August, when they occurred in 71 per cent of the scats.

TABLE 1.—*The 3981 scats in this table were gathered on the San Carlos Indian Reservation. The figures show the number of scats in which each food item was found*

ITEMS	HIGH RANGE	INTERMEDIATE RANGE			DESERT RANGE	TOTAL 3981
	Sept. 15 to July 5, 1943–44, 756 scats	Winter, 1942–43, 2093 scats	Nov. 1, 1943, to May 1, 1944, 283 scats	May 1 to Nov. 1, 1943–May 1 to July 17, 1944, 840 scats	9 scats	
Cattle	83	154	208	218		663
Peccary		1		2		3
Skunk		1				1
Coyote			1			1
Rock squirrel	4	8		1		13
Abert squirrel	1					1
Chipmunk	1					1
Pocket gopher	32	90	7	12	1	142
Pocket mouse		1				1
Kangaroo rat		1	2	7		10
Harvest mouse		2		2		4
Whitefooted mouse	7	14				21
Woodrat	3	4	1	5		13
Meadow vole	4	19		1		24
Mouse sp.?	21	96	6	19	1	143
Porcupine	6	4	1	2		13
Blacktail jackrabbit	1	2	1	3		7
Cottontail				8		8
Jackrabbit or cottontail	27	27	15	19		88
Gambel quail		5		4		9
Turkey	3					3
Duck		3				3
Flicker		1				1
Meadow lark				1		1
Sparrow		3		2		5
Bird	7	19		13		39
Eggshell				4		4
Lizard		5		4		9
Snake		3				3
Fish		1				1
Grasshopper	2	33		364		399
Beetle	1	19		49		69
Juniper	717	1959	11	15		2702
Prickly pear	1	28	29	323	4	385
Manzanita			12	14		26
Mulberry				40		40
Hackberry			14	1		15
Mesquite				1	5	6
Catclaw				1		1
Acorn, oak	1	1				2
Grass	1	14	1	7		23
Rag		1				1
Strap	1					1
Total No. of Occurrences						4,905

In early August the fruit of the prickly pear became ripe and replaced much of the grasshopper part of the diet. Of the 399 scats that contained grasshoppers, 224 contained 100 per cent grasshoppers, and 175, an average of 30 per cent grasshoppers. Summer collections of scats on the high ranges were not extensive enough to measure the importance of grasshoppers there. But since they were far less abundant on the high range, their importance in the diet probably was much reduced.

The species *Melanoplus mexicanus* was by far the most numerous in the droppings, just as it was in the field. The grasshoppers in four droppings were counted and the following numbers were found in them: 180, 135, 243, and 173. Using the average of this small sample, 183, the 399 scats contained about 51,000 grasshoppers. Grasshoppers are actually relished by the coyotes, for in the northern states, even where rodents are readily available, the coyotes make it a regular practice to feed on them.

On June 22, 1943, in a swale grown up in filaree (*Erodium cicutarium*), where grasshoppers were abundant and concentrated, I watched two coyotes catching them. As the coyotes moved, numerous grasshoppers rose before them, and many were snapped in the air, while others were pinned under the paws. In the same swale, about fifty Swainson hawks and thirty ravens were also feeding on grasshoppers.

A total of 69 scats contained beetles, mostly June beetles. In five of the scats, 100 per cent of the contents were beetles; in the others they averaged 25 per cent of the contents.

Juniper.—One of the surprising features of the coyote's food habits was the large amount of juniper berry (*Juniperus utahensis* and *J. pachyphloea*) in the diet. Of the 3981 scats gathered, 2702 or 68 per cent contained juniper. Usually juniper made up all or a large part of a scat in which it was present. In 2231 scats juniper made up 100 per cent of the contents, and in 323 of them at least 50 per cent. Both species of juniper were eaten, but because the common juniper is *J. pachyphloea*, it is the species chiefly eaten. *Juniperus utahensis* was observed only at lower elevations and only in a few localities.

On the intermediate range juniper was chiefly a winter food, but it was found eaten in the spring as late as April. During the summer grasshoppers and prickly pear were preferred to it. On the high range summer use was probably greater. It was here found eaten in July and several fresh scats picked up the middle of September contained only juniper.

The amount of juniper eaten in winter varied a great deal on the intermediate range. In the winter of 1942–43, 93 per cent of the 2093 scats contained juniper, while the following winter only 3 per cent of the 283 scats collected contained juniper. It appeared that cattle carrion was less available in 1942–43 and, therefore, the coyotes were forced to depend more on juniper. But many of the scats collected in 1942–43 on the intermediate range were gathered in juniper groves where coyotes had come to feed on the berries. Therefore, these collections increased the juniper incidence above average. Furthermore there was some accumulation of old scats in the grove which further increased the number of scats containing juniper. On the high range 717 of the 756 scats collected contained juniper. Since most of these were collected on the trails and highways, they were fairly representative of the food habits for the period studied.

Judging from the examination of small scattered collections of scats found outside the Reservation, it appears that juniper is an important coyote food in the Southwest. Fourteen fresh scats gathered in the middle of September on the highway between Fort Apache Indian Reservation and Showlow, four scats found on the Fort Apache Indian Reservation in June, and two scats picked up on the Navajo Indian Reservation, all contained only juniper. On the Hualpai Indian Reservation, of fourteen scats gathered on November 28, 1943, eleven contained juniper (100 per cent in eight of them).

Juniper is an important food for many animals. It was found in horse and in cattle scats, and was reported to be eaten by deer. The gray fox (*Urocyon*) and the wild turkey fed extensively on the berries.

Prickly pear.—On the intermediate range, from early August to late September the succulent fruit of prickly pear (*Opuntia*) was dominant in the diet. Of 437 scats gathered

on this range between August 4 and November 1, 1943, a total of 322 contained this item. In 235 of these scats only prickly pear was present, and in 87 others it made up an average of 57 per cent of the contents. In eating the fruit, care was taken to avoid the long sharp spines on the plant. Some fruits were carefully pawed off the plant, and others were gingerly bitten off. Only a few vigorous chews preceded swallowing, and the fruit passed through the digestive tract rather intact. When prickly pear became available it largely replaced grasshoppers in the diet.

Manzanita.—Manzanita (*Arctostaphylos pungens* or *A. pringlei*), although relished, was not abundant enough to furnish an important part of the food supply. Manzanita was first noted eaten on July 2 and the berries were still being eaten in late November. While climbing Navajo Mountain in southern Utah on September 18, 1943, I gathered fifty coyote scats on the trail. Twenty-five of them contained only manzanita berries and most of the others contained rabbit remains. Although juniper and pinyon grew on the slopes, each was represented in only a single scat. This would indicate that manzanita is more palatable than juniper or pinyon. At San Carlos a trapper captured eight or nine coyotes by setting traps near a patch of manzanita to which the coyotes came to feed.

Hackberry.—Hackberry (*Celtis reticulata*), fairly common in many dry stream beds, was found in fifteen scats. It made up the entire contents of three of them, and about half the contents of the other twelve. On November second and again on the fourth, a coyote was seen feeding on berry clusters which littered the ground under trees in which ravens had been feeding.

Mesquite.—Mesquite (*Prosopis juliflora*) is scarce on the upper ranges so it was not available to any extent where the food habits of the coyotes were studied intensively. Only one dropping containing mesquite pods was found on the higher ranges. On the desert range where mesquite is plentiful, it is no doubt an important part of the coyote diet. Of nine droppings gathered on the desert range five contained almost 100 per cent mesquite pods.

Catclaw.—Catclaw (*Acacia greggii*) was found in only one scat, but composed most of it. This shrub was sparingly distributed on the areas intensively studied.

Oak.—The acorn was found in two droppings, a single nut in one, and two in the other.

SUMMARY

From February, 1943, to July, 1944, 3981 coyote scats were collected on the cattle ranges of the San Carlos Indian Reservation. The incidence of the food items in the scats was as follows: cattle remains were found in 16 per cent of the scats, rodents and rabbits in 12 per cent, birds in 1.6 per cent, fish and reptiles in .3 per cent, grasshoppers and beetles in 12 per cent; juniper berries in 68 per cent; prickly pear in 9 per cent; mulberry, manzanita, hackberry, mesquite, catclaw, and acorn, combined, in 2 per cent; grass in .6 per cent. The food habits of the coyote were characterized by the extraordinarily large amount of vegetation eaten. The high incidence of vegetation in the diet was apparently due to a scarcity of flesh foods such as rodents and rabbits.

Moose, Wyoming. Received February 9, 1951.

NOTES ON THE RED FOX (*VULPES FULVA*) IN MISSOURI

By Harvey I. Fisher

Several times in early July, 1950, groups of red foxes were observed foraging in wheat stubble (maximum height of about 18 inches) in the bottomland east of the Grand River, four miles west of Triplett, Chariton County, Missouri. This area is floodplain, now protected by levees, and except where cultivated is covered with pinoak and pecan trees. It is in this timber that the fox dens are usually located. The dates given in Table 1 were the only ones on which observations were made; foxes were always found in the locations marked, when observations were made in the evenings.

The young were about two-thirds or three-fourths grown. Their coats were shaggier and duller than, and lacked the brighter reddish tones of, those of the adults.

If we may assume that the part of each field they used marked the general region of the den and of their hunting activities, we may get some idea of the minimum population; other families may have been present within the wooded area. On July 27, for example, as on August 3, two young were observed at each of the points marked X? on Figure 1, and probably represent other families. On July 27 all fields were visited between 5:00 and 6:00 P.M., and maximum numbers were found where expected; thus we can plot the location of six families. It may be seen that the families were slightly more than one-fourth mile apart; therefore, we may estimate that the radius of a family's activities is about one-eighth mile. This would mean an area of about 30 to 40 acres; to interpolate, this would make about 15 families per square mile. If one carried this further, it might be deduced that the population was at least 60 foxes per square mile in this particular area.

It was early noted that these foxes were always first observed in late afternoon, but not until plowing started on July 22, and I remained in the field from about 7:00 A.M. until dark (approximately 8:00 P.M. CST), were definite notes made.

On nine separate days, the first fox to appear was always recorded between 4:00 and 4:15. P.M. After 4:30 the number of foxes present never increased, and no foxes were seen in the field after sundown, although visibility was still good enough, for nearly an hour, to have observed them had they been present. On two mornings trips were made to the fields at daylight; no foxes were present.

The absence in the morning may, however, have been related to the feeding habits in the following manner. Usually the foxes were first noted in the furrow marking the boundary between plowed and unplowed land. They would move along slowly and occasionally stop to nose the last-turned dirt or to catch something in the edge of the stubble. Thus the fox was apparently utilizing the disturbed edge where the prey animals were more exposed, at least temporarily. In the morning there was no newly-turned soil.

The tractor was apparently commonplace for the animals and did not frighten them as long as I remained on the seat and the engine was working. Once the

machine was stopped, all foxes disappeared from that particular part of the field. The tractor seat gave good height to observe for at least 200 yards in any direction, and it was soon found that the tractor could be stopped for better observations, as long as the engine was roaring and I remained motionless. This, along with the seeming tameness of the foxes, permitted some close-range observation with binoculars.

Although as many as five foxes were seen at one time in a restricted part of a field, they did not feed as a close group. They entered the field singly, or at least were first observed as singles; the point of emergence onto the field was the same for each member of a group and was always used on subsequent days. Once on the field the family might be strung out over a distance of 200 yards; seldom were the foxes closer than ten yards to each other. When the tractor approached a fox too closely, the fox would move some 50 to 100 feet into the stubble, wait

TABLE 1.—*Numbers of foxes observed*

DATE	FIELD 1	FIELD 2	FIELD 3
July 22	3 young, 2 adults		
July 23	3 young, 2 adults		
July 25	1 young, 2 adults		
July 26	2 adults		
July 27	6 young, 3 adults	2 young	2 young, 1 adult
Aug. 2	3 young, 1 adult		
Aug. 3	5 young		
Aug. 21			2 young
Aug. 22			2 young
Aug. 23			2 young, 1 adult
Aug. 24		3 young	

until the tractor was past, and then regain the furrow, sometimes just 100 feet behind the tractor.

When the tractor approached a fox that was about 150 yards from the point of entrance to the field, and going away from it, the fox would run into the stubble and back toward the entrance point. Never were foxes seen to move more than about 200 yards from the entrance point. This distance was observed on all three fields and under varying conditions; it seemed to mark a boundary of some sort. Only once did a fox enter or leave a field, even though several were frightened, at any place other than those marked with an X on the figure. On this one occasion I approached more closely than usual to a feeding young fox and stopped the tractor engine. The fox immediately ran northward across Field No. 1, but did so very hesitantly, with much stopping, looking about, and retracing of steps. It spent nearly 20 minutes crossing 150 yards of plowing. As soon as the stubble remaining on the north side was reached, the fox ran around the east end of the field and went into the woods about 175 yards east of its point of entrance onto the field.

The tendency of several foxes (young and one or two adults, usually) to re-

main near one part or "territory" of the field was observed repeatedly, and strengthened my feeling that the areas shown on the map were centers of activity and that the groups of foxes seen here were discrete units or families.

Feeding foxes habitually walked slowly with head and tail low, moving the head slowly from side to side. When a food-object was sighted or smelled the tail and head, with ears cocked forward, were raised, and the animal remained motionless. The well-known "striking" with stiffened forelegs was the pattern of behavior always followed when catches were made in the furrow or on the stubble; in the one instance in which a fox made a capture (a frog which it pursued for about 15 feet) on the plowed ground, it simply reached out and seized the frog

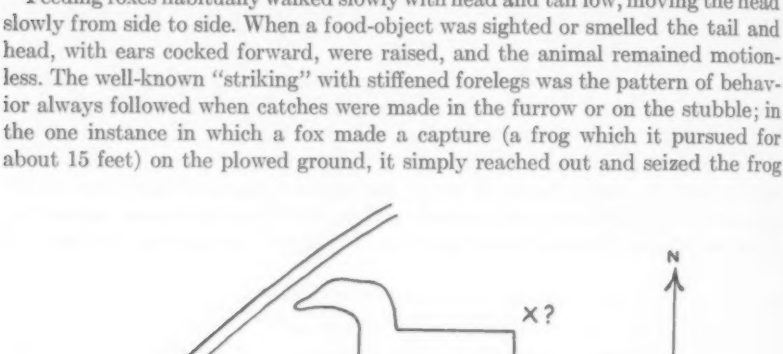

FIG. 1.—Map of area showing relative locations of fields and observations.

with the mouth. Perhaps the softness and unevenness of the plowed ground made the "striking" impossible, or perhaps the strike is only used on non-moving prey.

It became apparent later that the fox frequently moved into the same spot in the stubble with successive catches. This was observed in five young foxes seen separately—twice in each of two fields and once in another field—and thus could not have been a phenomenon associated with one fox or one family. Adults were never seen to exhibit the following behavior pattern which was identical in the five young foxes. The fox with its catch in the stubble stopped, looked about, dug a shallow depression in the soft, dusty soil with its forefeet, lowered its head into the depression, and then, pushing forward with its nose, moved dirt back into the concavity.

On three separate occasions, in two different fields, this procedure was watched with binoculars and the position of the cache carefully triangulated. After the lapse of two hours in each instance the site was investigated; the following materials were found: *Cache No. 1*; 3 *Microtus*, 2 *Mus*, 1 *Thamnophis* (posterior part only), 6 large grasshoppers. It should not be construed as meaning that the fox had eaten part of the snake. Many snakes were cut in two by the disk plow; their remains were frequently seen, and it is possible the fox simply picked up the available part. None of the other animals showed any evidence of being partly eaten. *Cache No. 2*; 4 *Mus*, 1 *Microtus*, 1 *Rana pipiens*, 2 grasshoppers. *Cache No. 3*; 2 *Microtus*, 2 *Mus*, 1 *Hyla*, 1 *Peromyscus*. The fact that only one *Peromyscus* was taken, compared with six *Microtus* and eight *Mus*, would seem to support the findings of Scott (Iowa State Coll. Res. Bull., 353:449, 1947) that *Microtus* is "preferred over *Peromyscus*." A cursory record of animals observed during one hour in the furrow beneath the slowly-moving tractor showed: 10 *Microtus*; 9 *Mus*; 6 *Peromyscus*; 12 cut parts and 6 living *Thamnophis*; 3 *Hyla*; and 37 *Rana pipiens*. Thus on the basis of availability, the fox would have taken two-thirds as many *Peromyscus* as *Microtus* or *Mus*.

The time interval may be unimportant for the fox may have buried prey prior to the time it was first observed; but the fact that foxes were never seen before 4:00 P.M., and that the caches were inventoried between 6:00 and 6:30 P.M. in each case, makes it seem likely that each cache represented about two hours of work for a fox. There is, however, the possibility that some animals were eaten during this period.

Each group of animals was replaced and covered. The sites were revisited just before dark; numbers 1 and 3 were gone, but number 2 was still present, even the next morning. It thus appears that the young foxes returned, within one hour, to secure the animals in two instances, although human scent must have been strong on the ground, the stubble, and the prey, for they were handled without gloves.

The reason for hiding the prey was never determined. Since the adults were not observed hiding the food, it could hardly have been stored for later transport to young in the den; the season of the year also tends to negate this possibility.

Perhaps the foxes were simply storing temporarily food in excess of their immediate needs. Since the total time available for hunting (as indicated by the hours during which foxes were observed each day) was limited to about three hours, it may be that hiding, for consumption later, enables more food to be obtained.

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RELATION BETWEEN LOW TEMPERATURE AND AVAILABLE FOOD TO SURVIVAL OF SMALL RODENTS

By Walter E. Howard

During cold weather small rodents of natural populations may succumb to what may be designated "cold weather starvation," the combined effect of low temperature and insufficient food to maintain body temperature. When individuals or groups of prairie deermice (*Peromyscus maniculatus bairdi*) living in a field in Michigan were without food during a late spring cold wave, some died of cold weather starvation (Howard, 1949: 32). Likewise, these and other small rodents confined in live traps during cold weather frequently die when without adequate food.

A small rodent requires more food in proportion to its body weight to maintain body temperature than does a larger animal, since it has a greater proportion of body surface to weight. Small rodents can survive exposure to temperatures far below that of their bodies. They have little or no means of resistance to heat much above their normal body temperature except by remaining in seclusion below ground. It seems unlikely that they voluntarily enter situations where they might die because of exposure to low temperatures. They do venture out in cool weather, however, and then it is necessary to eat several times as much food as in a warmer environment. Under the latter circumstances they may thus exhaust the local food supply and die due to "cold weather starvation."

This study was initiated at the Laboratory of Vertebrate Biology, University of Michigan, Ann Arbor, and continued at the San Joaquin Experimental Range, O'Neals, California, and in the Division of Zoology at Davis. Drinking water was supplied to all the caged animals in the survival experiments which follow. Acknowledgments are due Lee R. Dice, Oliver P. Pearson, and Tracy I. Storer for critically reading the manuscript.

No food or nesting material.—Laboratory and field experiments have shown that many small native rodents cannot survive overnight when exposed to freezing temperatures without food or nesting material. They are unable to break down and utilize fat deposits rapidly enough to maintain body temperatures, and consequently die with little loss in weight (Table 1, Exp. 9; Table 2, Exp. 18). At laboratory temperatures, however, small rodents may survive several days without food or nesting material by utilizing their body fat (Table 1, Exp. 8). When three female *Peromyscus maniculatus bairdi* were caged together outdoors without food or nesting material, one died during the first day. The minimum temperature had been −1° C. If they had not huddled together all three probably would have died.

A female *Peromyscus leucopus noveboracensis* was confined in a "presdwood" live trap approximately 3 x 3 x 8 inches without food. The trap was placed on the concrete floor adjacent to an outer wall of the laboratory at 4:15 P.M. on February 6, 1947. Another female was similarly housed, but provided with food. The outdoor temperature dropped to −13° C that night. At 8:00 A.M. the next day the mouse that had been confined without food was nearly dead and unable

TABLE 1.—*Relations of temperature, food, and nesting material to the survival of individuals and groups of Peromyscus*

EXPERIMENT NUMBER	NUMBER OF INDIVIDUALS AND SEX	SPECIES OF PEROMYSCUS	DATE (1947)	CONDITIONS DURING PREVIOUS 24 HOURS			BODY WEIGHT, GRAMS	REMARKS
				Cotton for Nesting	Minimum Air Temperatures °C (Lab. about 22°C)	Sunflower Seeds Supplied		
1	3♀	*P. l. noveboracensis*	2/5	Yes	Lab	Surplus	—	—
			2/6–3/10	No	−14 to +2	Surplus	—	Healthy
2	1♀	*P. l. noveboracensis*	2/6	Yes	Lab	Surplus	—	—
			2/7–3/10	No	−14 to +2	Surplus	—	Healthy
3	1♀	*P. m. bairdi*	3/15	Yes	Lab	Surplus	—	—
			16	Yes	0	None	—	—
			17	Yes	−3	None	—	Dead
4	3♀	*P. m. bairdi*	3/15	Yes	Lab	Surplus	—	—
			16	Yes	0	None	—	Two mice dead
			17	Yes	−3	None	—	Third mouse dead
5	1♀	*P. m. bairdi*	3/17	Yes	Lab	Surplus	—	—
			18	Yes	−3	None	—	Weak
			19	Yes	−2	None	—	Dead
6	1♀	*P. m. bairdi*	3/17	Yes	Lab	Surplus	—	—
			18	Yes	−3	15	—	Weak
			19	Yes	−2	15	—	Died later in day
7	1♀	*P. m. bairdi*	3/19	Yes	Lab	Surplus	—	—
			20	Yes	+7	30	—	—
			21	Yes	+7	30	—	—
			22	Yes	0	30	—	Dead
8	1♀	*P. m. bairdi*	3/20	Yes	12	Surplus	—	—
			21–22	Yes	Lab	None	—	—
			23	Yes	Lab	None	10.7	Weak
			24	Yes	Lab	None	10.2 (−0.5)	Weaker
			25	Yes	Lab	None	9.2 (−0.6)	Dead
9	1♂	*P. m. blandus*	3/21	Yes	Lab	Surplus	17.9	—
			22	Yes	0	None	16.8 (−1.1)	Dead (lost 6 per cent of body weight)

TABLE 1.—*Concluded*

EXPERIMENT NUMBER	NUMBER OF INDIVIDUALS AND SEX	SPECIES OF PEROMYSCUS	DATE (1947)	CONDITIONS DURING PREVIOUS 24 HOURS: Cotton for Nesting	Minimum Air Temperatures °C (Lab. about 22°C)	Sunflower Seeds Supplied	BODY WEIGHT, GRAMS	REMARKS
10	1♂	*P. m. blandus*	3/21	Yes	Lab	Surplus	28.1	Very obese
			22	Yes	0	None	24.5 (−3.6)	—
			23	Yes	+3	None	21.3 (−3.2)	—
			24	Yes	+10	None	19.9 (−1.4)	—
			25	Yes	−2	None	18.8 (−1.1)	Dead (lost 33 per cent of body weight)
11	1♀	*P. m. bairdi*	3/22	Yes	Lab	Surplus	21.9	Very obese
			23	Yes	+3	None	18.4 (−3.5)	—
			24	Yes	+10	None	16.8 (−1.6)	—
			25	Yes	−2	None	15.0 (−1.8)	—
			26	Yes	−4	None	12.2 (−2.8)	—
			27	Yes	−3	None	11.2 (−1.0)	Dead (lost 49 per cent of body weight)
12	1♀	*P. m. bairdi*	3/22	Yes	0	Surplus	—	—
			23	Yes	+3	60	14.0	—
			24	Yes	+10	60	14.2 (+0.2)	—
			25	Yes	−2	45	13.2 (−1.0)	—
			26	Yes	−4	45	12.9 (−0.3)	—
			27	Yes	−3	45	12.7 (−0.2)	—
			28	Yes	−2	45	12.3 (−0.4)	—
			29	Yes	+24	45	12.7 (+0.4)	—
			30–31	Yes	+23	Surplus	13.3 (+0.6)	—
			4/ 1	Yes	+3	Surplus	13.2 (−0.1)	—
			2	Yes	+4	Surplus	13.3 (+0.1)	Healthy
13	1♀	Same mouse as in Exp. 12	4/ 9	Yes	+19	Surplus	13.6	—
			10	Yes	+19	None	11.5 (−2.1)	—
			11	Yes	+21	45	12.3 (+0.8)	—
			12	Yes	+22	30	12.0 (−0.3)	—
			13	Yes	+22	30	11.8 (−0.2)	—
			14–16	Yes	+19 to +26	30	11.7 to 11.9	—
			17	Yes	−1	30	11.0 (−0.8)	—
			18	Yes	+1	30	10.1 (−0.9)	Dead (lost 26 per cent of body weight)

to walk, while the other was active and normal. Both mice had been taken from cages in the laboratory where previously they had a surplus of food. Two addi-

tional peromyscus, which presumably had escaped from their cages the previous day, also were nearly dead when removed from traps without food that were set on the floor to catch escapes. Both died later that day, being too weak to feed.

Nesting material but little or no food.—When nesting material is provided, small rodents require less food to maintain their body temperature and may survive one or more days at freezing temperatures without food (Table 1, Exp. 3, 5, 10, 11). Two mice, so situated, remained alive overnight at minimum temperatures of about 22 and 19° C (Table 1, Exp. 8, 13). When three mice were caged together, they reduced the rate of heat loss by huddling, and one survived for two days at freezing temperatures without either food or nesting material (Table 1, Exp. 4).

Even when nesting material is available, small rodents may not survive overnight at freezing temperatures if without food (Table 1, Exp. 9). To study this requirement, three male *P. m. bairdi* were caged together outdoors and nesting cotton provided. Three females were similarly caged, but without cotton. Neither cage received food the first day. The minimum temperature was −1° C that night and in the cage without nesting material one female died. The remaining five deermice were then offered 30 sunflower seeds each, a limited ration. The number of seeds each ate was unknown, but there is little doubt that sometimes—particularly on days when an animal died—a cage mate ate more than 30 seeds. The following day the second female died, and two days later the third was dead. Minimum temperatures were about 0° C. The three males lost some weight, but survived on 30 sunflower seeds apiece. The presence of nesting material apparently provided suitable conditions for them to huddle and remain lethargic or torpid much of the time, thus further conserving their limited rations.

Limited food.—At freezing temperatures two *P. m. bairdi* with nesting material died after several days when fed daily only 15 and 30 sunflower seeds, respectively (Table 1, Exp. 6, 7). Another female with nesting material lost weight at both freezing and laboratory temperatures on a ration of 30 sunflower seeds daily. She also lost weight on 45 seeds at freezing temperatures, but gained on the latter amount of food at laboratory temperatures (Table 1, Exp. 12, 13).

Food but no nesting material.—Small, freshly-trapped rodents can survive freezing temperatures without nesting material if they have a surplus of palatable and nutritious food; this has been seen either when caged in groups (Table 1, Exp. 1) or when solitary (Table 1, Exp. 2; Table 2, Exp. 14–27). As long as the animals had access to adequate food for fuel to maintain normal body temperatures, they did not die during freezing weather.

When field-caught animals have been caged in a laboratory for many months, they may not survive freezing temperatures without nesting material unless they are first acclimatized to low temperatures. When the temperature is suddenly lowered about 30 degrees, and to below freezing, they are likely to die with little loss of weight. This happened with the following animals that had been laboratory-housed for many months. They died during the first night at the following minimum temperatures, respectively: *P. l. noveboracensis*, −14° C; *P. boylei boylei*, −8° C; *P. truei gilberti*, −8° C; and *Perognathus inornatus inornatus*,

TABLE 2.—*Survival of rodents at freezing temperatures with a surplus of rolled oats but no nest material*

EXPERIMENT NUMBER	NUMBER OF INDIVIDUALS AND SEX	SPECIES	DATE	MINIMUM AIR TEMPERATURE °C, PREVIOUS 24 HOURS	PREVIOUS 24-HOUR CONFINEMENT; IF IN METAL TRAP, SIZE LISTED IN INCHES	BODY WEIGHT, GRAMS	REMARKS
14	1♀	*Thomomys bottae mewa*	1/1/48	—	Laboratory	76	Placed outdoors
			1/2-3/48	+4	Cage	75 (−1)	—
			1/4–22/48	−2 to +8	Cage	74 to 78	Healthy
15	1♀	*Thomomys bottae mewa*	5/8/48	—	Field	73	Placed in refrigerator
			5/9–18/48	−2 to +2	Cage	66 (−7)	Healthy
16	1♀	*Peromyscus maniculatus gambeli*	5/14/48	—	Field	19	Placed in refrigerator
			5/15–6/11	−7 to −1	2 x 2.5 x 6.5	15 to 17	Healthy
17	1♂	*Peromyscus boyei boylei*	5/14/48	—	Field	24	Placed in refrigerator
			5/15–18/48	−2 to −1	Cage	28 (+4)	—
			5/19–6/8	−7 to −1	2 x 2.5 x 6.5	25 (−3)	Healthy
18	1♂	*Peromyscus truei gilberti*	5/29/48	—	Field	28	Placed in refrigerator
			5/30–6/6	−5 to +2	2 x 2.5 x 6.5	—	Healthy
			5/7–8/48	−4	2 x 2.5 x 6.5	25 (−3)	Dead because no food
19	1♀	*Dipodomys heermanni tularensis*	6/2/48	—	Field	60	Placed in refrigerator
			6/3–11/48	−5 to −1	3 x 3 x 10	59 (−1)	Healthy
20	2♂, 2♀	*P. b. boylei*	1/3/49	—	Laboratory	—	Placed outdoors
	1♂, 1♀	*P. m. gambeli*	1/4/49	−8	2 x 2.5 x 6.5	—	—
			1/5/49	−8	2 x 2.5 x 6.5	—	—
			1/6/49	−7	2 x 2.5 x 6.5	—	Healthy
21	2♂	*Reithrodontomys megalotis longicaudus*	1/3/49	—	Laboratory	—	Placed outdoors
			1/4/49	−8	2 x 2.5 x 6.5	—	Healthy

22	2	*Citellus beecheyi fisheri*	1/3/49 1/4/49	— −8	Laboratory 3 x 3 x 10	— —	Placed outdoors Healthy
23	2♂	*Microtus californicus mariposae*	1/4/49 1/5/49 1/6/49	— −8 −7	Laboratory 2 x 2.5 x 6.5 2 x 2.5 x 6.5	63; 38 58; 37 60; 36	Placed outdoors — Healthy
24	8♂, 20♀	*Mus musculus*	1/5/49 1/6/49	— −7	Laboratory 2 x 2.5 x 6.5	— —	Placed outdoors One dead
25	2♀ 2♂, 2♀ 1♂, 1♀ 2♂ 1♂, 9♀	*T. b. mewa* *P. b. boylei* *P. m. gambeli* *M. c. mariposae* *Mus musculus*	1/10/49 1/11/49	— −9	Laboratory 2 x 2.5 x 6.5	— —	Placed outdoors Six dead *Mus*
26	2♀ 2♂, 2♀ 1♂, 1♀ 2♂	*T. b. mewa* *P. b. boylei* *P. m. gambeli* *M. c. mariposae*	1/11/49 1/12/49 1/13/49 1/14/49 1/15/49 1/16/49	— −8 −6 −1 −6 −5	Experiment 25 2 x 2.5 x 6.5 2 x 2.5 x 6.5 2 x 2.5 x 6.5 2 x 2.5 x 6.5 2 x 2.5 x 6.5	— — — — — —	Placed outdoors Fur on pocket gophers became wet after first day
27	2♂	*Citellus beecheyi fisheri*	1/3/50 1/4/50 1/5/50	−7 −6 −6	Field 6 x 6 x 18 6 x 6 x 18	— — —	Left outdoors Hardware cloth trap Healthy

−7° C. They were offered surplus food but no nesting material. The non-native, laboratory-reared *Mus musculus*, sometimes also died when exposed to below-freezing temperatures without nesting material, even when adequate food was available (Table 2, Exp. 24, 25).

Other laboratory-housed individuals, however, survived similar conditions (Table 1, Exp. 1, 2; Table 2, Exp. 14, 20–26). An adult male *Neotoma fuscipes streatori* that had been in a laboratory for more than one year survived for three days with a surplus of rolled oats but no nesting material when placed in a room kept at −6° C. An adult female *Thomomys bottae navus* that had been in a laboratory for five months survived at −7.8 to 0° C for seven days when given a surplus of rolled oats but no nesting material.

Live trapping.—Field-caught small rodents are able to survive exposure to below-freezing temperatures in live traps without nesting material as long as they are provided with a surplus of food (Table 2, Exp. 14–27). Two female *Dipodomys heermanni tularensis* and two female *Thomomys bottae mewa* were field-trapped on January 4, 1949, when the temperature dropped to −8° C. The traps were baited with a surplus of rolled oats, but had no nesting material. The animals were in good condition when removed from the traps, except that one *Dipodomys* apparently had frozen the tip of her nose to the metal door and consequently lost a little skin.

To explore this matter further, a male *P. b. boylei* weighing 24 grams was confined in a small live trap (2 x 2.5 x 6.5 inches) and put into a refrigerator. After 25 days in the refrigerator at daily minimum temperatures of −7 to −1° C he weighed 25 grams (Table 2, Exp. 17). The floor of the trap then was covered with dripping rolled oats that had been soaked in water for two hours. The minimum temperature was −1° C that night. The following day the underparts of the mouse were wet, but he had not changed in weight. The trap was then placed in water $\frac{11}{16}$ inch deep. Three hours later only the head and shoulders of the mouse were dry and the animal was dead the following afternoon. The minimum temperature had been −2° C. The dead animal was then dried and found to weigh 23 grams. This mouse apparently died from cold and wet rather than from insufficient food, unless the wet and partially submerged food was unpalatable.

Huddling.—Small rodents have a better chance of surviving cold temperatures when in groups; by huddling they reduce the rate of body heat loss and thereby decrease their needs for food and nesting material. Four wire cages were suspended outside a second-story window in Ann Arbor, Michigan, from January 29, 1947, to March 10, 1948, where they were exposed to minimum temperatures ranging from −16 to −4° C. Male *P. l. noveboracensis* were placed in the cages, a single individual in one, two in another, and three and four mice, respectively, in the remaining cages. Each cage was supplied with cotton and a one-pound coffee jar as a nest chamber. The animals were fed a limited amount of a prepared balanced diet daily. When the water supply in the cages was frozen, the mice were observed licking the ice and at other times they took condensed moisture from the inside of the nest chamber. Each cage received one portion of food for each occupant—four times as much food was placed in the cage with four mice

as was given the solitary mouse. All mice were alive on February 5; they were not checked on February 6. On February 7 the solitary individual and one from the cage harboring two mice were dead. From February 4 to 8, the daily minimum temperature dropped below −12° C; apparently the limited rations no longer sufficed to keep these two mice alive. After March 3 the rest of the mice were no longer fed. On March 7 the remaining mouse in the cage that originally contained two was dead. Also one each from the cages originally containing three and four were dead on March 7. When the nests were examined closely on March 10, the other two in the cage that had started with three individuals were dead, and one of the three remaining in the cage that began with four mice was almost dead.

Similar fates befall animals in the wild. Three *P. m. bairdi* in one natural nest died during a cold wave in Michigan; there was no food in their nest at the time (Howard, 1949).

When ten female *P. m. bairdi* were put in a small wire cage and exposed to a Michigan winter, they huddled in one nest in a coffee jar. When offered a surplus of food they cached uneaten seeds in the same jar. Finally they had gathered so many that on a morning when the temperature was −3° C the jar was full of seeds, and the mice were living in a cotton nest outside that afforded them little protection from the freezing weather. The backs of several of the mice were actually exposed to the cold air. Had these huddled mice been suffering seriously from the cold they probably would have removed some seeds from the jar.

Torpidity.—Three male *P. m. bairdi* were caged together outdoors for 27 days and provided with cotton nesting material and 90 (30 each) sunflower seeds daily. They had been starved for one day preceding the experiment. On this limited ration the mice did better at the lowest temperature, when they became torpid and reduced their metabolic activity. As the air temperature rose, less energy was needed to maintain body temperature, yet the total energy expended was greater since they lost weight. Presumably this was because they were less torpid and thereby had greater metabolic activity (Table 3). The sunflower seeds were eaten each night. Whenever examined at night all mice were active in both cages. During the day they did not move about, even when not torpid, but remained huddled in the nests.

During winter, *Peromyscus* in artificial nest boxes buried in the field were often aggregated in groups of a few to more than a dozen (Howard, 1949). Many were lethargic or torpid when examined during cold weather, and frequently they were unable to turn over when placed on their backs. One such torpid aggregation was handled a good deal while being measured, photographed, and inspected for fleas. They appeared slightly more active when the box was reexamined an hour later. Less dormant individuals became quite active after being held close to the author's body for about five minutes. When torpid, the eyes were closed, and the animals appeared as if hibernating. The rate of respiration, heart beat, and body temperature all were markedly decreased; but they survived, as indicated by later recaptures.

An approximation of the body temperatures of torpid *P. m. bairdi* was obtained

in the field from two torpid aggregations by inserting a thermometer between the huddled animals. In an aggregation of three, the external body temperature

TABLE 3.—*Relations of change in weight to degree of torpidity and temperature of three male mice (Peromyscus maniculatus bairdi) caged together and fed limited rations*

MINIMUM TEMPERATURES, PREVIOUS 24 HOURS	TOTAL DAYS MICE EXPOSED TO TEMPERATURE LISTED	3 MICE X DAYS	MICE TORPID WHEN EXAMINED X DAYS	AVERAGE DAILY CHANGE IN WEIGHT PER INDIVIDUAL, GRAMS
−1 to + 1° C	8	24	23 (96%)	+0.38
+2 to + 6° C	4	12	4 (33%)	−0.21
+7 to + 8° C	4	12	4 (33%)	+0.01
+9 to +18° C	11	33	2 (6%)	+0.08

TABLE 4.—*Air temperature about huddled, but not torpid, mice (Peromyscus leucopus noveboracensis) increases with additional animals in a nest*

NUMBER IN NEST	TEMPERATURE, DEGREES C	
	Outside Air	Nest Chamber
1	−14.4	+ 6.9
2	−14.4	+ 7.2
3	−14.4	+ 7.8
4	−14.4	+13.1
1	− .8	+11.2
2	− .8	+15.2
3	− .8	+16.1

TABLE 5.— *Condition of mice (Peromyscus maniculatus bairdi) with regard to whether they were active (A), both active and torpid (B), and torpid (T) depending on the temperature and number of individuals in each artificial nest on the Edwin S. George Reserve, Michigan*

TOTAL MICE IN NEST	AIR TEMPERATURE IN NEST CHAMBER, DEGREES C						
	−0.6	Zero	+0.6	+1.1	+1.7	+2.2	+2.8
1		A, A	A, A, A				
2		A					
3		A, T	T				A
4	B	T	B	T			B
5		B					A
6		B, T				B	
7						A	A
8							
9			T				
10		T					

was 10 to 12° C, when the air temperature was about −9° C, and the nest chamber 1° C. The external body temperature of four torpid mice was about 14° C, when the air temperature was about −7° C, and the nest chamber 1° C. When other factors were uniform, the air temperature in a nest chamber was higher as the number of animals present in the aggregation increased (Table 4). The

external body temperature of an aggregation of four active *P. l. noveboracensis* in an outdoor cage was 32° C when the air temperature was 0° C, and again when −14° C. By use of a thermocouple, Kendeigh (1945) found the internal body temperature of *P. m. gracilis* at rest to be 35° C or higher. Therefore, it is likely that the external body temperatures that I secured were two or three degrees lower than the internal temperatures of the huddled mice.

The rate of heart beat was determined for one torpid mouse (*P. m. bairdi*) in the field aggregation of four animals where body temperatures were measured. Upon pressing a finger over the mouse's heart, the very slow beat of 80 per minute was easily counted. The rate in an active deermouse is possibly 200 to 500 per minute depending upon its emotional state.

Often when *P. m. bairdi* were found torpid during the day, tracks were seen in the snow indicating that they had also been active at night. (Caged mice that were torpid by day were always active when observed at night.) In one outdoor box containing ten active individuals, tracks showed that only one had been out the previous night and that it ventured only four feet before returning to the nest. There was no stored food in the nest box. No *bairdi* living alone in a nest box was found torpid, and only one solitary torpid male of *noveboracensis* was seen. Single individuals probably are unable to become torpid during severe weather without the hazard of being frozen. As the number of individuals in an aggregation increased, the ability to become torpid during cold weather tended to increase (Table 5).

The environmental factors and instincts which stimulate some *Peromyscus* to become torpid and then later become active are unknown. Food is apparently not the only factor responsible for mice becoming torpid, because lethargic mice were found in nest boxes both with and without stored food. On the days when there were torpid mice in one box, active individuals were seen in adjacent boxes. It is not known how long the deermice can remain continuously torpid.

Discussion.—When one feeds small rodents housed in an unheated laboratory, it immediately becomes apparent that the animals eat more food during cold weather than when it is warm. The quantity of various kinds of food consumed at different temperatures has not been determined, but the amount required depends principally on air temperature, quality of food, and size of animal. According to Dice (1922) *P. m. bairdi* in a moist environment consumed food as follows:

Temperature, degrees C.....	0	21	28	32–34	35–36
Calories/day/gram of body weight.	0.82	0.58	0.56	0.46	0.33
Percentage of 0° consumption.....	100	71	68	56	40

When the temperature was lowered from 36° C to 0° C, then almost 2.5 times as many calories were consumed. Most small mammals (except possibly shrews) are able to survive one day or longer without food at ordinary laboratory temperatures; but it is doubtful that any trapped small rodent can exist overnight without food or nest material when the temperature drops much below 10° C, and even more doubtful when the temperature is below freezing.

An adult male *Neotoma fuscipes streatori* weighed 199.6 grams when placed in

a room at −6° C with surplus food but no nesting material. Two days later he weighed 198.6 grams. He was then offered only a small amount of rolled oats and the next day was too weak to feed and weighed 182.6 grams. After he died his weight was 181.7 grams. He lost only nine per cent in weight and, if he had not been fed a little food, he probably would have died sooner and lost even less weight. Kleiber (1947) showed that rats starved at environmental temperatures of 20, 30, and 38° C survived an average of 12, 17, and zero days, respectively. More food was required at 20° C than at 30° C, which was nearer their body temperature. At 30° C the starved rats lost an average of 41 per cent of their weight before dying, whereas between 18 and 28° C they lost only 29 per cent of their weight before death. At still lower temperatures they would have lost even less weight before dying. The nearer the environmental temperature is to that of the animal's body temperature, the greater can be the demand from the body tissues before death occurs. The rats subjected to the hot environment of 38° C did not survive the first day. Rats and smaller rodents obviously lack an efficient cooling mechanism and the habit of remaining below ground by day is therefore of marked advantage in summer as well as winter.

Under natural conditions, peromyscus conserves its food stores and survives cold weather by aggregating in groups of a few to upwards of a dozen (Howard, 1949). The aggregations were principally composed of family units. Offspring born in late fall, after the middle of September, remained at their birthplaces through the winter season. They did not disperse until they became sexually active the following spring. As a result, winter groups often comprised an adult pair and the survivors of their last two autumn litters. Unrelated mice occasionally became associated with these family units. In ten aggregations, individuals of *P. l. noveboracensis* were associated with others of *bairdi;* one group contained three white-footed mice and ten deermice.

Winter aggregations of peromyscus lessen the amount of individual metabolism required to maintain body temperature, thus decreasing the amount of food required by each. Pearson (1947) measured the metabolism of four adult house mice (*Mus musculus*) singly and with all four together. At 26° C four huddled mice used only 2.2 times as much oxygen as a single mouse. When moving about in the chamber, however, the four mice consumed four times as much oxygen as one animal alone. When huddled together they became essentially one larger animal of four times the weight, but having only about 2.5 times the surface area of a solitary mouse.

The ability of at least some species of *Peromyscus* to become torpid probably enables them to survive periods of severe weather. When torpid their metabolic activity is reduced, thus further conserving their food supply. Apparently these mice are able to conserve more food by becoming torpid, thus reducing their metabolic activity, than by aggregating, which reduces the amount of individual energy required to maintain their body temperature (Table 3).

Small rodents can be successfully taken alive during cold weather by placing an ample supply of palatable and nutritious food in the traps. Usually it is unnecessary to attach a nest chamber or to provide cotton or other nesting material

in live traps to keep rodents from dying. Sufficient food is more necessary than nest material. An ample supply of bait should be used in live traps whenever the minimum temperature approaches 10° C, and it is paramount to provide a surplus when the temperature drops to freezing or below, since small rodents require two or more times as much food at about 0° C as they do at laboratory temperatures. The presence of nesting material merely reduces the amount of bait that is required. The author has had few small rodents die in live traps that contained surplus food and no nesting material, except in those traps that were left too long in the sun.

Rolled oats and rolled wheat have proved satisfactory as bait to catch *Thomomys*, *Perognathus*, *Dipodomys*, *Reithrodontomys*, *Peromyscus*, *Microtus*, and *Mus*. About 15 grams of this kind of bait should be placed in each live trap. When trapping larger mammals, such as squirrels, a greater amount of food is probably not required unless temperatures are quite low, because with larger animals the food requirement decreases in proportion to their body weight as the environmental temperature declines. Laboratory chow pellets, dog cubes, and cotton seed cake did not seem to be good baits for producing quick heat; and individuals of *Peromyscus*, *Reithrodontomys*, and *Mus* fed these foods did not survive or even eat much when exposed to freezing temperatures without nesting material. Experience quickly shows whether or not a sufficient amount of the proper kind of bait is being used; if the bait is not adequate an occasional dead animal will be found in the traps during cold weather. If live weights of the captives are being recorded, it is desirable to provide a surplus of food so that the animals will not lose too much weight while confined, also, to examine the traps frequently.

The required amount of rolled oats when put into certain types of live traps may interfere with the trigger mechanism. If this occurs, most of the food can be supplied as whole grains. Llewellyn (1950) had no mortality in live trapping *P. l. noveboracensis* when he added a handful of shelled ear-corn to the traps, whereas he had nine of 29 mice die in traps baited only with a little peanut butter.

Some research workers have suggested that rodents might not withstand such severe temperatures if confined in live traps so small that they could not move around. The animals, however, do not need space for exercise to keep warm when in a cold environment (Table 2, Exp. 14–27); in fact, as the environment becomes colder the chance that the animal will move about becomes less. Caged *Peromyscus* became less active when subjected to below-freezing temperatures. Horvath (1948) found that mice, rats, and rabbits subjected to ambient temperatures of −35° C sat quietly in one place and exposed a minimum of surface, even though they had room for movement in their cages. Seemingly the need to conserve body heat increases as the temperature goes lower. When an animal crouches and exposes a minimum of surface, it lessens the heat loss.

Many persons who have had small mammals die in their traps during cold weather believed that it was due to the fur becoming wet from urine, which often occurs with trapped microtines. This may be true if there is insufficient bait,

because when the fur is wet more food is needed to maintain body temperature. Individuals also may become more susceptible to disease after their fur becomes wet. A surplus of food will enable a trapped animal to maintain its body temperature and also will lessen the hazard of damp fur by absorbing some of the urine.

Summary.—Small rodents under natural conditions or when confined in live traps may die from "cold weather starvation," the combined effect of low temperature and insufficient food. When the environmental temperature approaches freezing they require several times as much food to maintain their body temperature as in warm surroundings. Small mammals require more food in proportion to their body weight for this purpose than do larger individuals, because they have a greater proportion of body surface to weight. They are able to survive temperatures far below that of their body when afforded ample food. It is unlikely that small rodents in nature die from freezing alone, but they may succumb from cold weather when the food supply is insufficient to maintain body temperature.

When subjected to freezing temperatures and without food, small rodents apparently cannot marshal the energy in their body fat rapidly enough to maintain normal body temperature. When insulation is provided by nesting material or by huddling of two or more individuals, body heat is lost at a slower rate, and they may then be able to utilize their body fat before dying of starvation.

When small rodents aggregate and huddle, the per-individual heat loss is lessened. The prorata food requirement is further lessened if the animals become torpid, thereby reducing metabolic demands. Apparently less food is required to maintain peromyscus at freezing temperatures, when they can become torpid during the daytime, than is needed at warmer temperatures when the animals cannot become torpid and can only huddle and sleep by day.

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THE USE OF SKULL MEASUREMENTS AT THE SUBSPECIFIC LEVEL IN MAMMALIAN TAXONOMY, WITH SPECIAL REFERENCE TO *THOMOMYS TALPOIDES*

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The logical difficulty imposed by the gap between a state of nature and the formal system used by man in describing the universe is very apparent in attempts to recognize populations within a species by means of subspecific designation. In mammalian taxonomy variations in pelage color and skull measurements have been primarily the characters used at this level. In many cases skull measurements have been used to distinguish populations of mammals beyond the point where qualitative differences are recognizable. In addition, meristic characters have definite advantages in ease of analysis, tests of significance, and precision in setting limits to the range of characters.

The problem of how skull measurements can be used in expressing the existence of recognizable groups within a species seems to rest essentially on the concepts of ecology when taken in their broadest sense. All the morphological characters of any group of organisms are the result of an interaction between the group and the environment in which it has existed, either during its previous evolutionary history or during the life span of the individuals under inspection. Whether characters are fixed in the genetic matrix of the group through natural selection, mutation rate, or scattering of the variability is immaterial to the underlying ecological concept, for in all such processes environment plays a leading role, either directly or indirectly. For taxonomic use these morphological characters are divided into two groups, those due to the effect of the environment on the ancestors of the specimens under consideration and those due to the effects of the environment during the individual life spans of these specimens. Since the effects of the environments of the past are maintained by means of the genetic mechanism, the resulting characters have been termed genetic and the term environmental characters has been reserved for those due to present environment. Such terminology tends to confuse the underlying concept, but has been fixed by common usage.

At any rate, the division of differences between populations into two such groups is necessary for in order to describe the flow of phylogeny and in a search for stability those differences due to environmental influences during the life span of the individual have been ruled out. This necessity makes doubly difficult the problem of dealing with such criteria as body measurements for in all mammals total size will fluctuate considerably with changes in the present environment. By various methods it has been shown that size differences of the degree used in subspecific designation are fixed in the genetic matrix of certain intraspecies groups, notably in the genera *Peromyscus* and *Microtus*, yet under natural conditions these differences are so confounded by present environmental effects on size that the use of absolute size measurements is rendered uncertain. With the majority of mammal species, where even such fragmentary information is lacking, the use of absolute measurements appears unreliable.

Turning from absolute measurements of the skull, the taxonomist has used, in some cases, relative measurements, i.e. skull proportions. However, this does not solve the problem for ratios of this sort do not provide efficient comparisons between populations where the environment has an appreciable influence on size. It should also be noted that even body proportions are, at least in some cases, subject to environmental conditions. This has been shown to be true for fish and also for invertebrates. In adult mammals, while relative measurements may be subject to environmental influence, at least during embryonic development, the effect would appear to be less pronounced than in poikilothermal animals.

In a further attempt to render measurements more valuable, the taxonomist uses several levels of environmental effect to gauge their significance. He does this by using the amount of variability present in small geographical areas to interpret the variability present in larger areas. The size of the areas to be used depends on the mobility of the mammal involved, that is, the least area should be small enough so that interbreeding will provide the group involved with a similar genetic matrix yet be large enough to provide a diversity of environment. (It should also be small enough to preclude the possibility of naming any populations from practical grounds alone.) A second area should be large enough to permit diversity of genetic background yet permit the collection of animals from similar ecological niches. And finally, a still larger area should permit collections representing both diversity of genetic background and diversity of environment. While such considerations are implied in the naming of subspecies, mammals are rarely collected according to such a design. And so far as the author knows, no analysis of skull measurements, capable of yielding efficient comparisons of populations, has been made of such material. The present paper presents the results of an attempt to design and execute such an experiment.

Method.—While engaged in field work in Montana for the Montana Agricultural Experiment Station at Montana State College, it became possible to collect considerable numbers of skulls of the pocket gopher (*Thomomys talpoides*). These were later supplemented by examination of skulls in the United States Fish and Wildlife Service Collection through the courtesy of Dr. H. H. T. Jackson. Only one species of pocket gopher (*Thomomys talpoides*) occurs in Montana although a considerable but variable number of subspecies have been described by various workers. This species was thought to be suitable as an experimental animal as it apparently responded readily to both past and present environmental influences. It is widely spread and abundant throughout the state (Tryon, Mont. State College Agric. Exp. Sta., Tech. Bull. 448, 1949).

The specimens were collected and grouped according to the following three geographic areas (Fig. 1.). **Group I:** Within a single mountain range, the Bridger Mountains, in south-central Montana, three meadows were chosen. These meadows were located within a distance of two miles on the east side of the range, but differed markedly in kind and vigor of vegetation, type and depth of soil, and amount of soil moisture. The gophers from these three meadows differed significantly in size as indicated by total weight (Tryon, *loc. cit.*). Sixteen speci-

mens were collected from each of the three meadows. While close to each other, the meadows were separated to some degree by narrow tongues of forest. The area falls within the range of *T. t. fuscus*. **Group II:** Collections for this group were made from three mountain ranges, the Crazy Mountains, the Absaroka Mountains, and the Gallatin Range. All are located in south-central Montana and all border on one another, but are separated by valleys of considerable magnitude. Collections were made from locations representing several environmental types within each range, but roughly similar between each range. The population in the Crazy Mountains was named *Thomomys talpoides trivialis* and that in the Absaroka Mountains *T. t. kelloggi* by Goldman (Jour. Mamm., 20: 23–

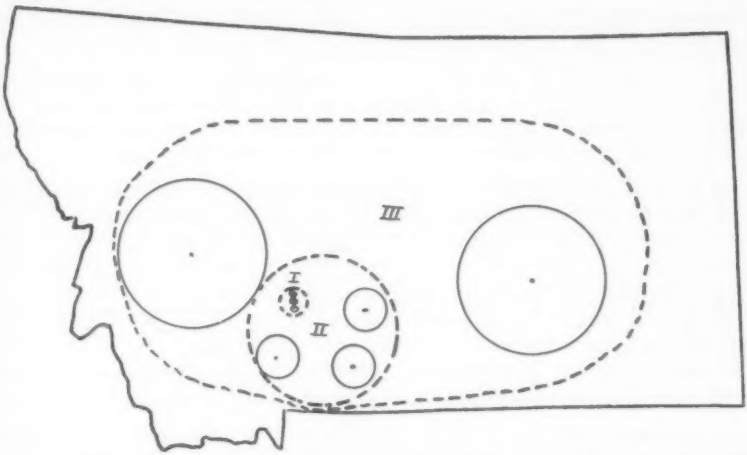

FIG. 1.—Map of Montana. The dotted lines show the areas in which the three groups of pocket gophers were collected. The location and extent of the collection ranges for each of the populations sampled within these areas is indicated roughly by solid line circles with a dot in the center. I, Bridger Mountain populations; II, populations from three separate mountain ranges; III, populations from western mountains and eastern plains.

44, 1939). The population from the Gallatin Range would fall within the range of *T. t. fuscus*. Twenty-seven skulls of each population were available for measurement. **Group III:** Collections for this group were made for comparison of the populations found in the western mountainous region and eastern plains region of Montana. *T. t. fuscus* occurs over most of the mountainous portion and *T. t. bullatus* in the plains region. Twenty-four skulls from each area were available for measurement.

All specimens used were mature adults at least one year old, having passed through one or more breeding seasons, and all were taken during the months of July and August. Since gophers reach sexual maturity as yearlings, and as most of their growth is accomplished during the first year, such specimens were believed to give adequate representation to the populations involved. Five skull

measurements were used, condylobasal length, rostral length, zygomatic breadth, width of rostrum, and interorbital distance. (The actual measurements may be obtained in mimeographed form from the author.) These were chosen for testing as they can be taken more precisely than most skull measurements and they represent the important proportions of the skull. Also, Dalquest and Scheffer (Amer. Nat., 78: 308–33, 423–50, 1944), in their detailed study of the Washington

TABLE 1.—*Comparison of the three areas from which samples of pocket gopher populations were drawn and of the size of the skulls of gopher populations within the areas as represented by condylobasal length*

GROUP	SIZE OF AREAS SAMPLED	ISOLATION OF POPULATIONS	ENVIRONMENTAL DIFFERENCES OF POPULATIONS WITHIN AREAS	ANALYSIS OF VARIANCE OF CONDYLOBASAL LENGTHS BETWEEN POPULATIONS WITHIN AREAS
I	Least	Least	Intermediate	Highly significant
II	Intermediate	Intermediate	Least	Not significant
III	Greatest	Greatest	Greatest	Highly significant

TABLE 2.—*Tests of significance (F) resulting from covariance analysis of the logarithms of skull measurements of populations from three different areas (Symbols follow Snedecor, 1949)*

	ROSTRAL LENGTH	ZYGOMATIC BREADTH	ROSTRAL WIDTH	INTERORBITAL
Group I (16 specimens from each of three adjacent meadows in the Bridger Mountains)	$F = 5.6$; $n_1 = 2$; $n_2 = 44$ Highly significant	$F = 1.86$; $n_1 = 44$; $n_2 = 2$ Not significant	$F = 3.0$; $n_1 = 2$; $n_2 = 44$ Not significant	$F = 3.1$; $n_1 = 2$; $n_2 = 44$ Not significant
Group II (27 specimens from each of three adjacent mountain ranges in south-central Montana)	$F = 18.96$; $n_1 = 2$; $n_2 = 77$ Highly significant	$F = 2.42$; $n_1 = 2$; $n_2 = 77$ Not significant	$F = 3.59$; $n_1 = 77$; $n_2 = 2$ Not significant	$F = 1.79$; $n_1 = 77$; $n_2 = 2$ Not significant
Group III (24 specimens from the mountainous region of Montana and 24 specimens from the plains region)	$F = 7.06$; $n_1 = 1$; $n_2 = 45$ Significant	$F = 6.88$; $n_1 = 1$; $n_2 = 45$ Significant	$F = 29.09$; $n_1 = 1$; $n_2 = 45$ Highly significant	$F = 15.60$; $n_1 = 1$; $n_2 = 45$ Highly significant

races of *Thomomys talpoides*, believed these measurements to be of the most systematic value. Measurements were taken with vernier calipers to the nearest tenth of a millimeter. Both males and females were used as analysis showed no significant difference between sexes in relative skull measurements.

In analyzing the skull measurements it was felt desirable, as previously mentioned, to compare the group populations on the basis of skull proportions. As a first step, to determine whether differences existed in total size, condylobasal length was used in an analysis of variance between populations within the

groups. Significant differences existed between the populations in Group I, but not between the populations in Group II (Table 1). Since the populations in Group I were associated with environmental differences and those in Group II were not, it is likely that the differences in total size of the skull were related to environment. Since, under such conditions, ratios do not lead to efficient comparisons, it was decided to use covariance analysis in which the means of the skull measurements of the different sized populations can be adjusted to the basis of a common skull size before testing for significant differences. A covariance analysis was, therefore, run for each of the three groups; condylobasal length was used for the X value and the corresponding skull measurement was used for the Y value in each case. (Symbols follow Snedecor, Statistical Methods, Iowa State College Press, 4th ed., 1946). All measurements were first transferred to logarithms as has been shown necessary in using covariance analysis with this type of material (Snedecor, *loc cit.*).

Discussion.—If, by using covariance analysis, the effects of variations in size are removed from the comparisons of skull measurements between populations then a more rigorous interpretation of the results becomes possible. Any significant differences in skull measurements that are left are felt to be essentially due to differences in skull proportions and thus are at least more apt to be fixed in the genetic matrix of the population. Also, since total size of skull was affected in Group I where environmental effect was marked and not in Group II where environmental effect was not strong, it is felt that at least up to geographic areas of the size utilized in Group II total size differences are largely the effects of present environment acting within genetic limits. In Group III where both considerable geographic range plus marked environmental differences were involved the differences in total size were correspondingly much greater than in Group 1.

In regard to skull proportions, the only significant differences in the populations from the adjacent meadows of Group I were those associated with rostral length. Likewise at the next level where the populations from different mountain ranges were compared the only difference again was that associated with rostral elongation. In Group III all of the skull proportions represented by the measurements taken showed significant differences. (Table 2).

While no attempt is made in the present paper to revise the subspecies of *Thomomys talpoides* in Montana, several interesting generalizations may be drawn from the information in Table 2. An attempt is usually made in taxonomy to associate the degree and number of differences in characters of populations with the amount of time that has elapsed since some degree of isolation of the population occurred (remoteness of common ancestry). In regard to the skull measurements under consideration the presumably more remote common ancestry of the populations from Group II was not associated with any more differences in skull proportions than occurred in the populations from adjacent meadows (Group I). In Group III where common ancestry was considerably more remote, however, significant differences appeared in all the skull proportions examined.

The appearance of significant differences in rostral length in both Group I

and Group II can be argued both ways, i.e. either as due to environmental effects (Group I) or as due to genetic control (Group II). Since there were no differences in total size of skulls of the populations tested in Group II, however, it may well be that the rostral differences are genetic. This would indicate that the meadow populations of Group I are isolated despite their geographic proximity. Considering the habits of pocket gophers this is possible. It is of course impractical to attempt to name ecotypes of such limited range as the meadow populations of the Bridger Mountains, even if the single criterion of rostral elongation was considered sufficient difference.

None of the populations in Groups I or II showed any consistent differences in qualitative characters. In Group III where significant differences in skull proportions existed, differences in pelage color and number of teats were also present. These two Group III populations, by any criteria, would be considered suitable for taxonomic recognition.

It would appear, therefore, that in this case, skull measurements do not permit any greater degree of taxonomic recognition of populations than that permitted by qualitative characters. Whether this holds in general for pocket gopher populations or for other kinds of mammals calls for further experimentation. It does indicate the need for careful evaluation and perhaps the revaluation of the use of skull measurements at the subspecific level.

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A NEW TECHNIQUE OF ANIMAL CENSUS, WITH EXAMPLES

By D. A. MacLulich

Census taking is basic to intelligent management of wildlife resources. Various methods of trapping small mammals for the purpose of obtaining comparative indices or absolute census of their abundance have been discussed and used by many workers. A representative assortment of methods is covered in the papers listed under literature cited.

The ideas developed here and the trial trapping were worked out in the summer of 1938, but the war and subsequent commitments prevented publication. In the meantime some of the concepts, but not the central one, appeared in the later papers mentioned above. This study was done as part of the biological research programme in Algonquin Provincial Park, Ontario, while the author was a member of the staff, and the superintendent, F. A. MacDougall, is to be thanked for supporting the work.

A method of trapping and computation is presented which measures the range of movement or home range and the population density of suitable species. The sample area must be about one-quarter mile square or larger. The method gives average information about a fairly large sample of animals within a short time. It is complementary to live trapping which slowly gives information about individual animals.

DEVELOPMENT OF FORMULAE

A trap line or quadrat, given sufficient suitable traps with a good bait and reasonable time, will catch most of the animals whose ranges of movement overlap the area enclosed by the traps. The majority of resident animals of most species of mice will be harvested within four nights trapping, see MacLulich (1940) and Hayne (1949). Dice (1938) must be given credit for emphasizing the idea that the census area will consist of the area enclosed by the traps plus a strip around it half the width of the average range of movement, or as wide as the animals' average radius of action. The range of movement, R, will usually be different for various species and even, within a species, for each sex, age class, season of the year, habitat, and degree of abundance. The males, or certain age classes at certain times of the year, may be found to wander and not be attached to a particular area. The formulae described below still apply to such animals without home ties, but the term 'home range' loses its validity, becoming simply a mathematical average range of movement of the animals concerned during the number of days for which the traps were set. Because animals whose ranges do not reach the traps may yet overlap part of the surrounding strip of the so-called 'area depopulated' the term 'census area' will be used instead.

The symbols used in what follows and their meanings are:

A. Area from which the animals are drawn, the 'census area' or so-called "area depopulated."

C. 'Catch.' The number of animals using the census area. This will usually refer to only one species, sex, and age class at a time, and estimation by removal graph method or by Lincoln Index method.

H. Area of range of movement.

L. Length of a line of traps.

N. Population per unit area, such as ten acres.

P and Q. Dimensions of rectangular trapping quadrat.

R. Mean diameter of home range or range of movement during the trapping period. The range may be considered as hexagonal; actual ranges are of course extremely variable in shape, but a hexagon is better than a square, rectangle, or circle as a general average shape that will fit together without interspaces.

Util. Territory in use as a proportion of the total area, i.e. the degree of utilization of area.

U. Unit area, such as ten acres.

V. Number of animals of a given species, sex, and age class which overlap each other on the average.

1 and 2. Subscripts used to designate symbols referring to two separate quadrats.

Census area.—The formulae for the census area A are: For rectangular trapping quadrat; $A = (P+R)(Q+R) - 0.22R^2$ [Eqn. 1]. For a linear trap line: $A = RL + 0.78R^2$ [Eqn. 2].

The census area can not be estimated until a value for R, the range of movement, is determined. Note that when the dimensions of the trap line are in yards

the census area may be obtained in acres by dividing by 4840. In these formulae it is assumed that the corners of the area from which animals are drawn will be arcs of circles, with centres at the corners of the trapping quadrat, or ends of a linear trap line and radius equal to half the mean range of movement. In the case of a 55-yard square quadrat and 100-yard range, this correction to the census area amounts to minus 9 per cent.

Number of animals using census area.—Three assumptions, which appear logically sound, are made with respect to the number of animals, C, of the species, sex, and age class being considered, using a census area at a given time in a fairly homogeneous habitat: 1. The number of animals using the census area, otherwise called 'animals exposed,' may be estimated from the catch of reasonably efficient traps and bait by the Lincoln Index method (1930) or the Removal Graph method of Hayne (1949). 2. The number of animals using the census area will be proportional to the size of the census area, A. 3. The number of animals using the census area will be proportional to the density of population, N. At this point, having done the trapping, we have estimated the number of animals of each species, sex, and age class using the census area, but since the size of the census area is still unknown the population density has not been determined.

Principle of simultaneous trap lines for estimating range of movement.—The main new idea of this paper is that by simultaneously trapping two quadrats of widely different size in the same habitat the two unknowns, range of movement and density of population, may be calculated. A requirement is to find an area of the specified habitat which is reasonably uniform in vegetation and physiography so that the animal population may be assumed to be fairly uniformly distributed. This area must be large enough to accommodate the two quadrats without interference and with an untrapped margin around and between them. For a uniform population the density of animals will be equal for both census areas, hence the ratio of the census areas to each other will be equal to the ratio of the numbers of animals determined from trapping. Given the dimensions of the quadrats the ratio of the census areas depends on the size of the range of movement only, that is, the average range of movement can be found by solving an equation developed as follows:

$$\frac{C_1}{A_1} = \frac{C_2}{A_2} = \frac{N}{U} \text{ population density, therefore: } \frac{C_1}{C_2} = \frac{A_1}{A_2}$$

That is, substituting from Eqn. 1: $\frac{C_1}{C_2} = \frac{(P_1 + R)(Q_1 + R) - 0.22R^2}{(P_2 + R)(Q_2 + R) - 0.22R^2}$

Multiplying and collecting terms, we get:

$$0.78\left(1 - \frac{C_1}{C_2}\right)R^2 + \left[(P_1 + Q_1) - \frac{C_1}{C_2}(P_2 + Q_2)\right]R + \left(P_1Q_1 - \frac{C_1}{C_2}P_2Q_2\right) = 0 \quad \text{[Eqn. 3].}$$

Similarly, if the second trap line is a straight line of traps of length L the equation becomes: $0.78\left(1 - \frac{C_1}{C_2}\right)R^2 + \left[L - \frac{C_1}{C_2}(P_2 + Q_2)\right]R - \frac{C_1}{C_2}P_2Q_2 = 0$. These

are both quadratic equations in one unknown and they may, either one, be solved for R, the average range of movement of the species, sex, and age class of animal during the time of trapping. Denoting the coefficients above by a, b, and c, the solution is:

$$R = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

At least one of the trap lines must be a quadrat; two linear trap lines can not be used together because the absence of any enclosed area makes the solution indeterminate. Essentially, there are two unknowns, R and N, hence two independent trapping equations are necessary for their determination as outlined above.

To avoid laborious calculations, Figure 1 contains graphs for various pairs of trapping quadrats and lines, allowing R to be read off over the ratio of animals exposed to trapping, C_1/C_2.

Area of movement or area of range.—The area of movement may legitimately be called 'area of home range' only in cases where other evidence indicates that the animals in question do stay for most of a season within a limited area. It may be found, for instance, that the breeding females of a species have a home range, but males have not. However, this distinction is irrelevant to this method and the average area covered during the trapping period, whether the animal be nomadic or home-centred, will be found. The formula for a hexagon is used for area of movement as follows: $H = 0.75R^2$ [Eqn. 5].

Estimation of population density.—Having determined the average range of movement and having calculated the census area by Eqn. 1, the population per 10 acres may be estimated by this formula, with A in acres: $N = U \times \frac{C}{A} = 10 \times \frac{C_1}{A_1}$ or $= 10 \times \frac{C_2}{A_2}$ [Eqn. 6].

Degree of utilization of area.—A measure of the degree of utilization of the area will be the proportion of the total area of the occupied ranges to the unit area, divided by a factor, V, for overlapping. The equation is as follows: Utilization of area $= \frac{H \times N}{U \times D}$ [Eqn. 7]. Overlapping of ranges can be accurately evaluated only by live trapping, but in the cases where the total area of ranges of movement exceeds 100 per cent coverage, a minimum factor for overlapping can be calculated by assuming 100 per cent utilization and solving for V. The existence of unused territory within a range has not been taken into consideration. For no overlap, V equals one. V is the average number of animals using any occupied territory.

TRAP-LINE TECHNIQUES: HABITAT

The use of a type map is desirable for selecting trapping areas to sample the main habitats. It is essential for compiling an estimate of population based on population density and area of each main habitat. It is wise to leave an untrapped zone about 150 yards wide outside the trap lines, hence a quadrat and a line of

traps require an area 500 to 600 yards square. The Royal Ontario Museum of Zoology has issued Mammal Checking Cards which include a useful form and guide for making an ecological description of any habitat.

Number and distribution of traps.—Certain requirements and suggestions may be summarized as follows:

(a) Traps must be suitable to catch the desired animals. Live traps are to be preferred for areas to be censused annually; beyond that the merits of various traps will not be discussed here.

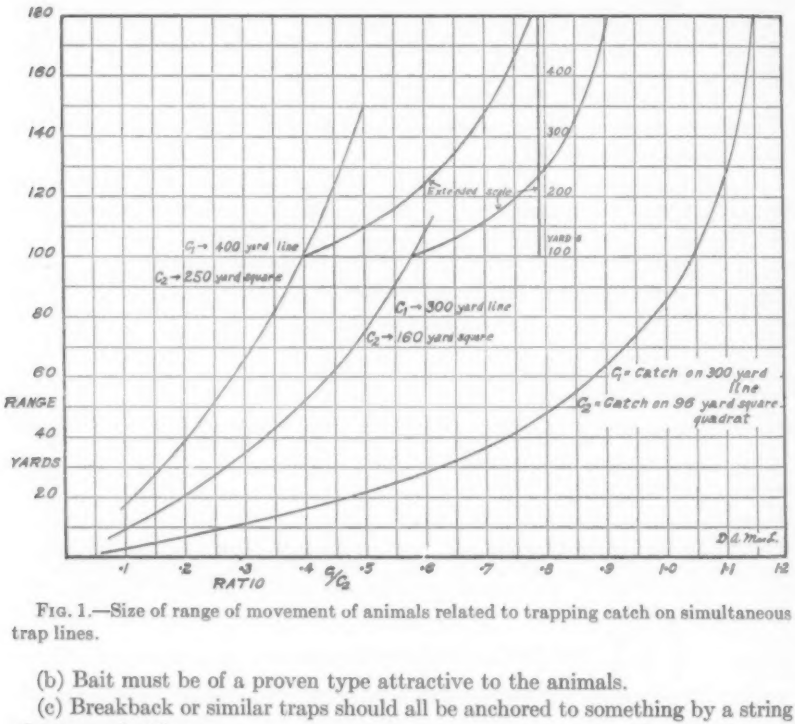

FIG. 1.—Size of range of movement of animals related to trapping catch on simultaneous trap lines.

(b) Bait must be of a proven type attractive to the animals.

(c) Breakback or similar traps should all be anchored to something by a string about two feet long.

(d) There must be enough traps to accommodate the number of animals available to be caught. A 96-yard square quadrat may commonly catch 50 or more animals in three or four nights and should have 250 to 350 traps.

(e) There should be a systematic spacing of traps over the area, but on the boundary of a quadrat the traps ought to be spaced two or three times as closely as on internal lines. The spacing suggested for a 96-yard square quadrat consists of 17 lines 6 yards apart of 17 traps per line, with traps at intervals of 6 yards, and around the boundary extra traps between those mentioned at intervals of 3 yards. Measure the quadrat and mark its borders on trees, by stakes, or by other

means, then use a stick 3 yards long as guide in positioning traps. For a quadrat 160 yards square use 17 lines of traps spaced 10 yards each way, except for 5-yard spacing around the border, a total of 353 traps.

(f) It is suggested that each trap should be placed at the spot, within two feet of the measured trapping point, which the trapper considers most likely to be visited by an animal.

(g) The spacing suggested on a 300-yard line is 1½ yards, which requires 201 traps. Use a spacer stick, but make the total length of the line accurate by measuring it with a tape. A line uses traps more efficiently than a quadrat because each trap extends into new territory, therefore, fewer traps are needed on a line.

(h) Use a small paper bag for each animal caught, writing the trap location on the bag. At the camp keep full records of sex, age class, size, and breeding condition, and preserve at least a few of the mammals and of their parasites. Mark the location of each animal caught on a map of the trap line which shows natural features as well as trap locations.

ACCURACY

The accuracy of ecological measurements is far below that of physical measurements, which makes it all the more important to assess the statistical accuracy of results of animal trapping. It is only by such estimation of error that the significance of apparent changes in abundance can be assessed. An illustration and suggestion of one trend such studies can take will be examined now.

Artificial test case.— All figures used in this section are synthetic examples only, but they serve to illustrate possible methods of approach. Burt's (1940) maps of home ranges of *Peromyscus leucopus noveboracensis* for August 4 to September 23, 1935, were repeatedly fitted together to make two large maps, one for females and one for males. On these artificially built-up maps, which had however ranges of natural size and shape, the above method of trapping and analysis was applied in 'dry swim' fashion by counting home ranges overlapped by appropriate squares marked on translucent paper to represent the quadrats. Fifty quadrats of each size, 10, 55, and 150 yards square, and fifty straight lines 400 yards long, were counted. From the frequency distribution of the catch the probable error of the catch from any single quadrat or line was estimated. For female white-footed mice the probable errors were: for the 10-yard quadrat, 30 per cent; for the 55-yard quadrat, 16 per cent; for the 150-yard quadrat, 6.8 per cent; and for the 400-yard line, 15 per cent of the catch. The catches of males had larger probable errors, and, for instance, a 150-yard quadrat would be required to give the same accuracy as a 100-yard quadrat would do for females.

Comparison of catch with Poisson Distribution and Fiducial Limits.—The frequency distribution of size of catch for any one quadrat size did not fit the Poisson Distribution. Similarly the Fiducial or Confidence Limits for Poisson Frequency Distribution for 95 per cent probability (Ricker, 1937) are far wider than the variation in catch that was encountered. For instance, the mean catch of female white-footed mice in the 150-yard quadrats was 12 with the smallest catch 10 and the largest 15 out of 54 counts, whereas the fiducial limits for a

mean of 12 and 95 per cent probability are 6 and 21. Those fiducial limits would have meant that 2 or 3 counts out of the 54 would have been smaller than 6 or larger than 21. The failure to fit the Poisson Distribution and the narrowness of the variation in the catch compared with Poisson fiducial limits mean that the catch is not distributed at random, but rather it must be governed by more definitely regular habits and conditions.

Accuracy of estimate of range of movement.—To assess the probable error of determination of the range diameter all possible combinations of the observed catches were tabulated, their individual probabilities paired up and accumulative frequency graph drawn for each of the pairs of trap lines shown below. From these graphs the probable errors were read off with the results shown in Table 1, ignoring a certain amount of skewness.

TABLE 1. —*Probable errors of range diameter of white-footed mice in synthetic case*

SEX AND AGE	RANGE DIAM. BY AV. AREA	PROBABLE ERRORS OF RANGE DIAMETER		
		10-yd. & 55-yd. quadrats	55-yd. & 150-yd. quadrats	150-yd. quad. & 400-yd. line
breeding ♀	49 yds.	30 per cent	55 per cent	35 per cent
adult ♂	74 yds.	60 per cent	60 per cent	60 per cent

TABLE 2.—*Example of probable error of population estimate in synthetic case*

	MEAN VALUES	50 PER CENT LIMITS	
		Lower	Upper
Catch, 150 yd. quadrat	12 animals		
400 yd. line	7 animals		
Range	56 yards	36 yards	74 yards
Census area	4.5 acres	2.9 acres	5.9 acres
Population per 10 acres	27 animals	41 animals	21 animals
Probable Errors		+14 or +50%	to −6 or −22%

Accuracy of estimate of population density.—Using female white-footed mice and the 150-yard-square quadrat with 400-yard line as an example we get results shown in Table 2. Notice the probable range in population density, between 20 and 40 practically, with the most probable value of 27 animals nearer the lower figure.

Selection of dimensions of trap lines.—The determination of range diameter with a given accuracy can be done with the least effort by the use of a quadrat and a line, each of such a size as to yield a catch of the same accuracy, corresponding to that desired for the range. The number of animals caught would be about the same in the quadrat and in the line, i.e. the ratio C_1/C_2 would be nearly equal to one. However, such ideal trap lines would be of different sizes for each kind of animal with different size of range and this is impractical; therefore, a compromise is necessary. The ratio C_1/C_2 is dependent only on the dimensions of the trap lines and on the size of the range of movement, R; the ratio is independent of population density, N. To measure the ratio accurately the trap lines

must be large enough to give reasonably large catches. The catch is dependent on all three things, trap line dimensions, R, and N. Considerable effort was put into preparing graphs of range of movement R over C_1/C_2 for many different combinations of quadrats and lines, and a 96-yard-square quadrat with a line 300 yards long appeared to be a good compromise for small mammals with ranges below 130 yards in average diameter, see Fig. 1. An interesting experiment would be the trapping of two quadrats, 96 and 160 yards square, and a line 300 yards long in the same habitat to compare results using each possible combination in pairs.

EXAMPLES

A small experiment, conducted at the end of August and beginning of September, 1938, involved only 2732 trap-nights. Because circumstances have prevented the accomplishment of more extended field work it was thought desirable to report this illustration of the method as far as it went.

Pairs of quadrats 10 yards square and 55 yards square, respectively, were trapped with ordinary breakback traps. The areas were, therefore, as 1 to 30. The small quadrat received 121 traps and the larger one 126 traps, approximately the same number, but spaced farther apart. The traps were set for four nights in most cases. One pair of such quadrats was in a forest of hemlock, yellow birch, and sugar maple, and two pairs in a forest of spruce, white pine, and white birch, a total of six quadrats.

The catch comprised 153 animals representing eight species. The catch and analysis of results for the two more common species are presented in Table 3. The figures themselves must not be taken too seriously, but they serve to illustrate how this method can be applied.

Clethrionomys gapperi.—The two 10-yard quadrats in spruce, white pine, and white birch forest disclosed 15 and 13 red-backed voles, respectively, and the two 55-yard quadrats caught 28 and 30, which confirms the uniformity of the habitat and populations. In this forest the average diameter of the home range of breeding females is estimated to be 51 yards, whereas the corresponding size is 120 yards in the hemlock-yellow birch-sugar maple forest. Some confirmatory evidence is found in the estimations of the home range of the young which are approximately in the same ratio to each other. The breeding females and young show good consistency in the catch and the results appear to have some reliability. Calculations for adult males were abandoned due to the great irregularity in the catch, which suggests that the adult males have larger and more irregular ranges of movement than do the adult females. Red-backed voles appeared to be many times more abundant in the spruce forest than in the hemlock type, 80 individuals or 16 families per 10 acres in spruce forest compared with 14 individuals or $3\frac{1}{2}$ families in hemlock forest. Notice how misleading the catch can be by comparing the ratios of the population figures with corresponding catch figures. For making these rough estimates of population the adult males have been assumed to be as numerous as the breeding females. Attention is also drawn to the estimation of area of movement, percentage utilization, and number of animals overlapping.

TABLE 3.—*Small example of determination of range of movement and population by simultaneous trap line method*

SPECIES	AGE CLASS AND SEX	ANIMALS EXPOSED TO TRAPS		RATIO C_1/C_2	RANGE OF MOVEMENT (R) YARDS	AREA OF MOVEMENT (H) ACRES	CENSUS AREA		POPULATION PER 10 ACRES (N)	UTILIZATION OF AREA (MAX) PER CENT	NUMBER OF ANIMALS OVERLAPPING (V)
		10-yd. sq. quadrat	55-yd. sq. quadrat				A_1	A_2			
Habitat: White spruce-white pine-white birch forest. Two pairs of quadrats											
C. gapperi	breeding ♀	1 + 1 = 2	4 + 3 = 7	0.29	51	0.4	0.6	2.2	16	64	1
" "	adult ♂	3 + 0 = 3	2 + 1 = 3	1.0					16?		
" "	sub-adult & young	11 + 12 = 23	22 + 26 = 48	0.48	110	1.9	2.4	5.1	48	100	9
Totals		15 + 13 = 28	28 + 30 = 58						80		
Habitat: Hemlock-yellow birch-sugar maple forest. One pair of quadrats											
C. gapperi	breeding ♀	1	2	0.50	120	2.2	2.8	5.7	3.5	78	1
" "	adult ♂	1	6	0.17					3.5?		
" "	sub-adult & young	6	9	0.66	229	8.1	9.4	13.1	7	100	6
Totals		8	17						14		
P. maniculatus	breeding ♀	1	2	0.50	120	2.2	2.8	5.7	3.5	78	1
" "	adult ♂	0	3	—					3.5?		
" "	sub-adult & young	8	15	0.53	135	2.8	3.7	6.6	23	100	7
Totals		9	20						30		

Peromyscus maniculatus.—This species appeared to be more abundant in the hemlock type than in the spruce type, where the sample was too small for determination of range. In the hemlock type the size of range of breeding females was 120 yards and that of the young was of the same order of size. The population worked out at 30 individuals or $3\frac{1}{2}$ families per ten acres. Here again the uniformity of catch of breeding females and the irregularity in that of adult males shows up. The same condition was evident in Burt's data already used in the study of accuracy.

Another example.—Professor R. H. Manville of Michigan State College allowed the use of data on live-trapping which he did in northern Michigan in 1941. The quadrats were 100 yards square with 121 traps at 10 yards spacing. On the map showing where each animal was caught nine sub-plots were marked out in a systematic manner, each 40 yards square, and the catch which would have resulted from each was read off the map. The average of the nine sub-plots was used with the total catch of different animals on the 100-yard quadrat to

TABLE 4.—*Red-backed vole, Clethrionomys gapperi, in white cedar swamp, in Michigan, August, 1941. Figures for 40-yard quadrat are estimates from map of the larger quadrat*

	ADULT FEMALES	ADULT MALES
Animals caught, 100-yd. square, C_2	3	4
Animals caught, 40-yd. square, C_1	1.2 average	1.3 average
Range diameter, R	92 yds.	46 yds.
Area of range, H	1.3 acres	0.3 acres
Census area, for 100-yd. square, A_2	7.2 acres	4.3 acres
Census area, for 40-yd. square, A_1	3.2 acres	1.4 acres
Population per 10 acres, N	4	9
Utilization of area	54 per cent	31 per cent

make the estimations in Table 4 by the Simultaneous Trap-line Method. It is realized that the above pairs of data are not independent; the figures for the 40-yard quadrats must be too small and hence the calculated range too small. However, they serve to further illustrate the method.

RECOMMENDATIONS

It is recommended that trial trapping be done with two quadrats 96 and 160 yards square and a line 300 yards long.

An annual stock-taking scheme should be based on a habitat type map of the region, on which suitable areas of each major habitat are selected for sampling by the simultaneous trap-line method. For such annual work the use of live traps would be desirable.

SUMMARY

A method is presented of estimating range of movement of a given species, age class, and sex of animal during the trapping period. From that and the number of animals caught the density of population may be estimated.

This Simultaneous Trap-line Method uses a pair of quadrats of widely different size or a quadrat and a straight line of traps.

It is a relatively quick method which gives average data on range and population and is complementary to conventional live trapping which slowly gives individual data on range and population.

A start is made in assessing the accuracy of estimates of range of movement and of population density. This is essential for two reasons: Firstly, it is on information of this sort that the most efficient use of trapping effort may be planned; Secondly, a knowledge of the accuracy of population estimates is necessary to assess the significance of differences in results from year to year, from place to place, or habitat to habitat.

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A REVIEW OF THE STATUS OF WOODLAND CARIBOU (*RANGIFER CARIBOU*) IN ONTARIO

By A. de Vos and Randolph L. Peterson

Glover M. Allen (1942: 315) made the following statement in his "Extinct and Vanishing Mammals of the Western Hemisphere:" "To sum up, the woodland caribou, once so common in the muskeg areas from Nova Scotia to western Minnesota and north to southern Labrador and James Bay, is now everywhere so greatly reduced that it is in actual danger of extermination."

Although it is generally conceded that two races, *Rangifer caribou caribou* and *R. c. sylvestris* occur in Ontario, the limits of distribution and taxonomic status of each remains yet to be thoroughly studied. Unfortunately, such studies cannot be carried out at this time due to the scarcity of specimens in collections. The only complete specimen from Ontario in the collections of the Royal Ontario Museum at present is a female collected in the Sioux Lookout district, 20 miles northeast of Red Lake on March 15, 1949. Other material consists of a few skulls and antlers.

In addition to published records, the following information is based on personal interviews with local residents, data from the annual questionnaires of Royal Ontario Museum of Zoology, written reports of the staff of the Ontario Department of Lands and Forests and other personnel, as well as personal field work of the authors. Individual observations of many co-operators are too voluminous to include here, but are held on file either at the Royal Ontario Museum or the Department of Lands and Forests.

We are especially indebted to Dr. C. H. D. Clarke, Supervisor of Wildlife Management, Department of Lands and Forests, and his staff who were most helpful in providing data on the present status of woodland caribou in the Province.

Former distribution and abundance.—Following glaciation in the Great Lakes area, it would seem likely that the re-dispersal of caribou took place from both an unglaciated forested area of Wisconsin and a similar area south of the limits of glacial ice in northeastern United States. It also seems reasonable to suppose that the two presently-recognized races originated from these two areas (*R. c. caribou* in the east and *R. c. sylvestris* in the west) to give a re-dispersal pattern similar to that found by Peterson (1950) in moose. On the basis of ecological succession it can be assumed that this reoccupation would have preceded that of moose which, in turn, took place prior to white man's earliest historical records. Further studies along these lines are needed. In eastern Ontario, the Nipissing-Great Lakes system may have constituted a barrier to post-glacial range expansion. No records are available to indicate that they occurred south of that system in recent times. However, at one time caribou of some kind occupied the southern Ontario region as evidenced by fragments found in interglacial deposits of that region. After the Nipissing-Great Lakes system gave way to the present system there would seem to be nothing to prevent caribou from crossing into the Parry Sound or Algonquin Provincial Park regions, but apparently they never did so.

From the time of early exploration by white men up to the close of the nineteenth century the status of caribou is poorly known. A few scattered references in the literature seem to substantiate the assertions of older residents that caribou were abundant all across the north-central portion of the Province where over much of the area they were at one time the sole cervid. They were apparently abundant on Manitoulin Island at the time of white man's early exploration of the area. The account of Nicolas Perrot (Blair, 1911: 221) indicating that 2400 moose were snared there by the Indians during the winter of 1670–1671 almost certainly referred to woodland caribou, not moose.

Several of the older residents were interviewed concerning the population level of caribou by the end of the 19th century. They indicated that this species was then more common or at least as common as the white-tailed deer is today in the same range. One interesting statement can be mentioned in this connection: Mr. J. Cross of Sibley Peninsula, an area of approximately 110 square miles, estimated that the caribou population of the area was at one time at least 500 head. The present deer population might be estimated at approximately the same level. Miller (1897) stated that caribou were very abundant on the north shore of Lake Superior.

Among the original notes of Mr. Charles W. Nash, former Provincial Biologist for Ontario (1903–1926), the following appears in Nash's handwriting in a note book headed "Order Ungulata" now on file at the Royal Ontario Museum of Zoology. The note appears to have been written about 1910.

"R. caribou—Caribou are very abundant on the north shore of Lake Superior where they replace the Deer and Moose of the Canadian Zones. I saw heads, antlers and jaws of Caribou at White River, Peninsula Harbour, Schreiber and Nipigon.

"A wet pasture among the hills a mile or more northeast of Peninsula Harbour is a favorite feeding ground of these animals. Their fresh foot prints resembling cattle tracks were to be found every morning, but I only once saw one of these animals. The pale color of this Caribou's sides and buttocks made him a conspicuous object as he trotted leisurely about the edge of the marsh and among the stunted spruces and tamaracks with which it is bordered."

By the beginning of the twentieth century the woodland caribou seemed to be declining rapidly across the Province.

In Fort Frances Forest District (Fig. 1) according to Snyder (1938) one resident reported the last caribou as having been seen in the southern part of Western Rainy River District in 1894. He records, however, that about 1911 a caribou was shot northeast of Emo between Carpenter and Burris townships. The last to be seen at the south end of Lake of the Woods, in Spohn Township, was in 1916.

Around Fort Frances herds of caribou were not uncommon until about 1900. The last specimen seen in any settled part of the district was about twenty years ago.

South of the border in Minnesota, caribou were comparatively abundant about 1855–65, but declined thereafter to the point where ten animals were obtained

from Saskatchewan in an effort to "restore and, if possible, build up the herds in that area. . . . Apparently, however, these too have disappeared, inasmuch as recent efforts to obtain information as to their whereabouts have failed" (Surber in Swanson, Surber, and Roberts, 1945: 24).

In Kenora Forest District caribou started to disappear from the southernmost section around 1913–14. While still plentiful before 1915 along the east shore of

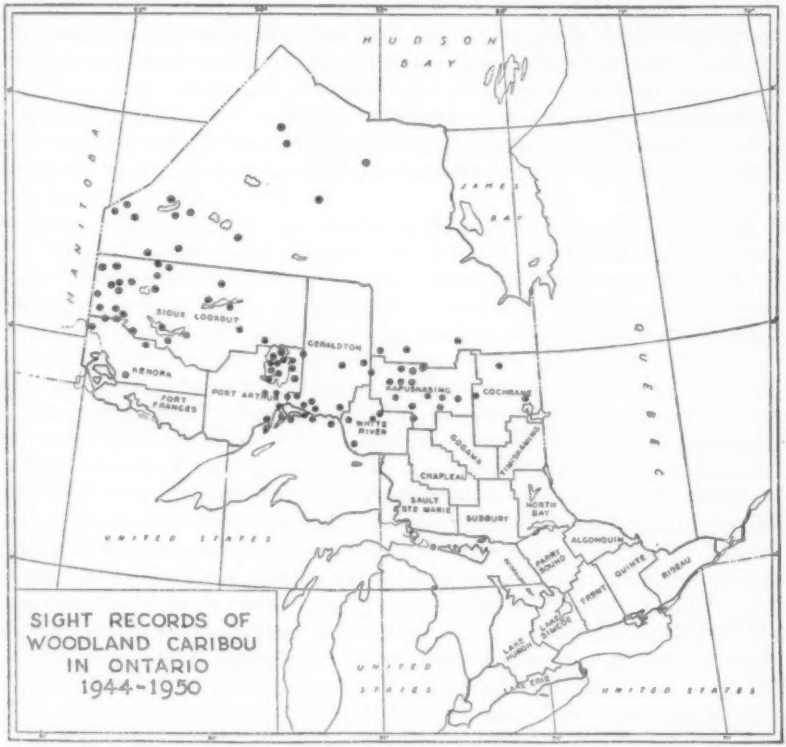

FIG. 1.—Map of Ontario showing the organization of Provincial Forest Districts and the distribution of sight records of woodland caribou made during the years 1944 to 1950.

Lake of the Woods, they largely disappeared from there about 20–25 years ago, although several reports indicate that a small, isolated herd may still persist in one large wilderness area. They have apparently vanished from the southeastern part of the District.

In the vicinity of Sioux Lookout caribou were apparently not present after 1910. However, few small herds may have lingered on in the southern part of the Sioux Lookout Forest District until the present time.

In Port Arthur Forest District, caribou were still numerous in the eastern

section by the turn of the century. Dymond (Dymond *et al.*, 1928) states that while the caribou was formerly the only deer found in the District, it became uncommon especially after the construction of the National Transcontinental Railway across the north end of Lake Nipigon between 1908 and 1912. Caribou started to decrease on Sibley Peninsula after about 1907. The largest herd reported to have been seen there was one of 59 head. The animals were still a common sight on Black Bay Peninsula nine years ago.

In Geraldton Forest District caribou were still numerous throughout its entirety by the turn of the century. Around 1907 they were still common on the islands in Lake Superior. One fisherman estimated that there used to be ten times as many caribou on the islands as there are moose now.

While apparently still quite plentiful in Chapleau Forest District up to the turn of the century, the species faded away rapidly afterward. In Township 32, forty head were seen about 1900, but by 1914 none was thought to be present in that area.

Snyder (Snyder *et al.*, 1942: 119) gives the following information about the former distribution of the caribou in the Sault Ste. Marie Forest District:

"It seems apparent that many years ago, before settlement, Woodland Caribou occupied some of the islands of the St. Mary River and the St. Joseph Channel, and that they must have once travelled through the area of our 1931 survey. Mr. James C. Perry told us that a small island on the Michigan side was known, at least locally, as Caribou Island. A lake east and north of Desbarats is named Caribou Lake. Mr. Hugh Erwin told us that an occasional caribou was said to be present in 1886 when he first settled there but it was prior to 1870 that they occurred with any frequency. In a letter on file in the R. O. M. Z. dated November 26, 1904, Mr. Joseph Towley wrote to the late J. H. Fleming, from Sault Ste. Marie, as follows: 'You were asking about caribou: They are quite plentiful on a range of hills fourteen miles north of the Soo; also on a range back of Echo Bay and Garden River, but I do not know of any points south of those mentioned. They follow the highest ranges as a rule.' Clarke (1938) states that according to old settlers the Pancake Bay area was once a fine caribou country. In the Toronto 'Mail and Empire' for October 8, 1931, and in the Toronto 'Telegram' for March 15, 1934, reports indicated an increase in Woodland Caribou to the north in this general section of Ontario."

During his travels (1760–1776) Alexander Henry reported finding caribou on Caribou Island, Lake Superior, and mentioned the presence of many skeletons (Quaife, 1921: 219–22). He also visited Michipicoten Island, but did not mention caribou. It is not known when the animals disappeared from Caribou Island, but today no big game animals occur either there or on Michipicoten Island.

In Cochrane Forest District, caribou used to appear regularly in winter at Lake Abitibi until about 1921 (Snyder, 1928).

Further south in the vicinity of Ridout, Sudbury District, Soper (1920) found only stragglers, reporting that one animal was killed a few years earlier, but that they were then very rare.

About the year 1775 caribou were listed as the sole big game animal of Lake

Nipissing by Alexander Henry (Quaife, 1921: 31). Later Murray (1857: 137) classed caribou as "by no means uncommon" for the same area. Other early records are given for the Ottawa Valley by Lett (1884). It is apparently not known just when the caribou disappeared from the Lake Nipissing region, but it seems almost certain that none was left by 1900.

In Nash's original notes (*op. cit.*) he wrote as follows: "In a letter of Oct. 3rd, 1905, Mr. M. Carr, ex M P P for Parry Sound says: 'During my 30 years stay in Parry Sound hunting all kinds of game, I have yet to meet a caribou or a man that has seen one. I do not believe they came so far south, the nearest I know of is New Liskeard and just now you cannot find them in that neighbourhood, but prior to settlement they were there.

"They are much more shy than even Moose and much more so than Deer. A friend of mine got some up the White River 20 miles north of New Liskeard and he says they can't be found south of that point. They go in droves from five to twenty in a bunch'. (s.) Milton Carr"

There is little information available concerning the population of caribou in Ontario during the last two decades. The annual reports of the former Department of Game and Fisheries contain very vague statements which do not seem to be based on much field observation.

The "Report of Special Committee on the Game Situation" sessional paper, No. 32, 1933, contains the following information (pp. 42 and 43):

"From the Report of District Superintendent Ward, Sioux Lookout (October, 1932) we take the following statement: There appears to be little, if any, improvement in the numbers of caribou, an occasional small herd being reported north of Nakina, Tashota and Allanwater, at the latter place small bands or an occasional single one being seen both on the south as well as the north side of the railway, as is also the case from there west to the Manitoba boundary. Several small bands have been reported by trainmen as being seen south across the track near Farlane, while one trainman reported having seen one herd of over twenty at this point.

"District Superintendent Frazer, Fort William (November, 1932) reported: I beg to advise that a few scattered herds of caribou are to be found in different parts of this district, some in the country south of Dinorwic, between there and Fort Frances, and some around English River country, between Ignace and Fort William. There are also a few to be found north of Schreiber, between the C. P. R. and C. N. R. main line north, and a few on the Islands of Nipigon Lake at the north end. The main herds of caribou to be found in this district are, I believe, on the islands in the Superior Game Preserve; and from the best sources of information available I would estimate this herd at between 50 and 75 animals.

"District Superintendent Lyness, Sault Ste. Marie (November, 1932) also reported: There are plenty of caribou north of Amyot between the C. P. R. and the C. N. R. They have increased steadily in this section for the last few years and have spread east and west; a few have been seen in the west end of the Chapleau Game Preserve.

"District Superintendent Parks, North Bay (December, 1932) reported: I

have to advise that a few of these animals have been seen in the vicinity of Oba, while a few others were located in the Townships of Moberly and Wilhelmina, about forty miles north of Timmins."

Present distribution and abundance.—The woodland caribou has disappeared from much of the southern perimeter of its former range. Figure 1 indicates the present distribution of caribou based on the more reliable sight records made during the period 1944–50.

Woodland caribou may be regarded as absent from Ft. Frances Forest District and practically so from the Kenora District except for the isolated small herds which are reported to persist in the area east of Lake of the Woods and in the northwestern section adjacent to Sioux Lookout Forest District. Herds were reported in 16 different locations in the latter District in the winter of 1949–50, a few comprised of as many as 100 head. The species likely has disappeared from the part of the District situated south of Sioux Lookout. While occasional reports come from the northeastern and central section, the animals seem to be most abundant in the western part of the District.

In Port Arthur Forest District caribou are absent in the southwest. They occur in small scattered herds in the eastern part of the District along the north shore of Lake Superior and on islands in Lake Nipigon. A few have been reported between the two latter locations.

Probably less than a hundred caribou survive in the Geraldton Forest District. These are found in small scattered bands throughout it. The population is apparently highest on the islands along the north shore of Lake Superior. The authors have observed animals in both the St. Ignace and Slate Island groups.

In Kapuskasing Forest District few caribou survive. These are in the northern and western section.

Very few scattered herds remain in Cochrane Forest District. There is apparently a fair population in the adjoining portion of Quebec and undoubtedly there is some movement of animals across the Provincial boundary. It has yet to be determined whether or not the range is continuous from north central Ontario into Quebec. A few years ago caribou were considered to have disappeared entirely from the east of a line drawn from the east end of Lake Superior to James Bay (Allen, 1942; Anderson, 1947), but more recent reports would indicate a possibility that the range may again be regarded as continuous or has actually remained so.

A few caribou seem to survive in White River Forest District.

For all practical purposes they may be considered as now absent from their former range in the Forest Districts of Sault Ste. Marie, Chapleau, Gogama, Timiskaming, Sudbury, and North Bay, although an occasional straggler may possibly wander into the northernmost sections adjacent to their present known range.

In that area north of the organized Forest Districts, known as the Patricia Portion of Kenora, caribou occur in widely scattered herds. They are absent from a fringe along the Hudson Bay in the northwestern part of the Province, but still seem to be present close to the west shore of James Bay. Reports indicate

that caribou occur along the Severn and Winisk rivers. Three caribou were observed north of Sutton Lake in January, 1949, which is the closest observation to Hudson Bay reported in recent years. The Royal Ontario Museum of Zoology has specimens of shed antlers taken from the Arctic tundra area of Cape Henrietta

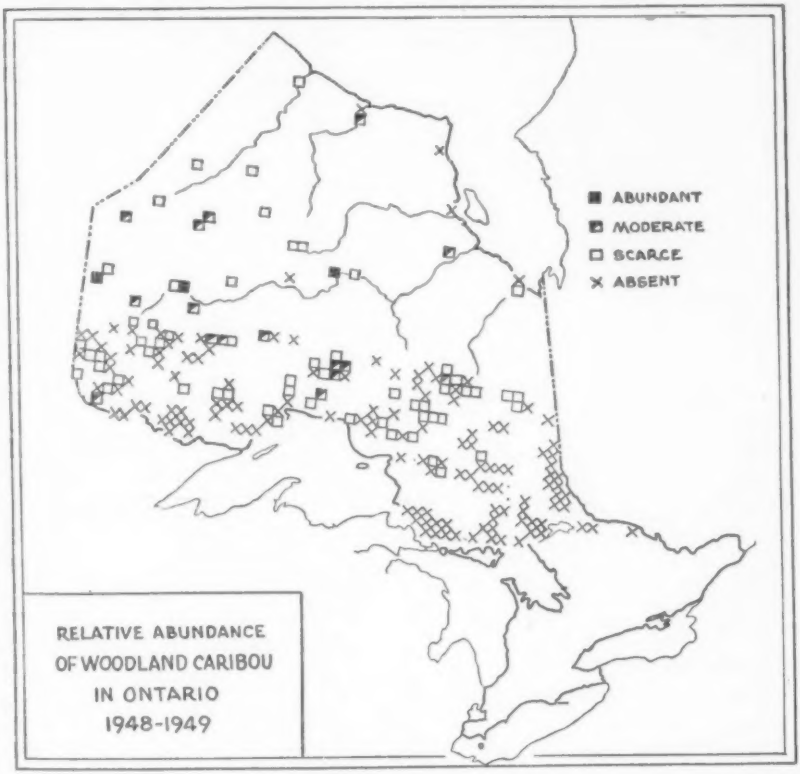

FIG. 2.—Map of Ontario indicating an estimation of relative abundance of woodland caribou based on the 1948 and 1949 regular annual questionnaires of the Royal Ontario Museum of Zoo ogy.

Maria where they are apparently now absent. A fairly good herd is known to exist near the mouth of the Attawapiskat River.

In the northwestern section of Patricia the picture is complicated by the apparent invasion of barren ground caribou (*R. arcticus*) during recent winter seasons, particularly in the Sachigo River area.

A Province-wide summary of the more recent trends in the caribou situation is indicated in Figs. 2 and 3 which are based on the 1948 and 1949 results of the annual questionnaires of the Royal Ontario Museum of Zoology. Fig. 2 represents

an expression of the opinions of these regular observers regarding the relative abundance of the existing populations. Fig. 3 represents similar opinions on the trends in population changes.

From Fig. 2 it seems quite clear that caribou cannot be regarded as generally abundant anywhere in the Province, but that the centre of greatest abundance

FIG. 3.—Map of Ontario indicating an estimation of the 1948-1949 trends in woodland caribou populations.

lies in the northwestern section comprising Northern Sioux Lookout Forest District and the western section of Patricia.

If Fig. 3 can be regarded as a true expression of fact, the general trends in the populations are encouraging. If an east-west line is drawn across the Province at a level joining the northern shores of Lake Abitibi and Lake Nipigon, the area to the north might be regarded as favourable for an improvement in caribou populations while that area to the south remains critical.

It is extremely difficult to arrive at an estimate of the total populations of

caribou in Ontario today. Such an estimate is made especially difficult because of the poor coverage possible in the vast expanse of the Patricia area where the woodland caribou appears to have its present stronghold. South of a Lake Abitibi-Lake Nipigon line it seems almost certain that there are no more than approximately three or four hundred caribou remaining. North of that line it seems likely that there are at least 1,000 animals, and possibly two or three times that number. In other words, on the basis of available information, the present caribou populations might be estimated at between 1300 and 3000. The encouraging reports from the northern part of the Province should be followed most closely to determine more accurately the future trends of woodland caribou in Ontario.

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COLOR MUTATIONS IN A SMALL, PARTIALLY ISOLATED POPULATION OF POCKET GOPHERS (*GEOMYS BREVICEPS*)

By W. H. McCarley

A series of twelve pocket gophers (*Geomys breviceps*) from a locality five miles southwest of Colbert, Bryan County, Oklahoma, show four apparently independent mutations. These pocket gophers came from a colony estimated to be comprised of eighteen individuals on March 3, 1950, the date this work was completed. Deep alluvial and red clay soils combine with two continuous creeks to form ecological barriers which serve to keep this small population partially isolated from other populations of the same species.

The relationship of the barriers to pocket gopher dispersal in the area occupied by the small population is shown in Figure 1. Area I is wooded. This area of gumbo soil was subject to flooding prior to 1946, and was covered with water during all except the summer months. Areas II and III are hillsides that have been eroded down to the characteristic red clay of this region. Area II is possibly of sufficient width to restrict the movements of gophers, since it is approximately 50 to 75 yards wide. I doubt that area III, which is only 15 to 20 yards wide, would seriously limit their dispersal. Area IV is forested. The soil is a dark sandy loam, easily worked by gophers, although I was unable to find any evidence of their activity here. Area V is a cultivated field of sandy loam, and while the gophers are not active in this area, it does not constitute a barrier. Sandy Creek is a continuous stream maintaining a flow of water two to three inches deep and four to five feet wide. This creek has had water in it continuously since 1936. The drainage ditch was dug in 1946, and it has had a continuous flow of water six inches to one foot deep and approximately three feet wide since that date. While these streams may not be complete barriers they would certainly impede the distribution of the pocket gophers.

The four mutations occurring in the gophers from this locality are shown in Table 1.

The grizzled mutation is the most prominent and is apparently similar to the mutation described by Clark (Contrib. Lab. Vert. Gen., U. of Mich. No. 7, 1938) in the deer mouse (*Peromyscus maniculatus*). Specimen number 1972 exhibits this mutation to the greatest degree. This specimen is over-all white with a very few scattered brown hairs. Number 1545 is a darker specimen, with a larger proportion of brown hairs. In this specimen, the greatest concentration of white hairs is in the cephalic region. The sites of capture of these two individuals are indicated on Figure 1. It is interesting to note that this mutation was observed to occur only on the south side of Sandy Creek. The sites of capture were 175 yards apart with the drainage ditch acting as a separating barrier. Since the drainage ditch was not present until 1946, there are two possible explanations for the presence of this mutation in the two separate areas. Either the gene responsible for this condition was present in both areas before 1946, or the mutation has occurred since 1946. If this mutation did occur after 1946, the question arises as to how a gopher crossed the drainage ditch to disperse the

mutant gene from the point of origin. It is possible that a gopher crossed the bridge spanning the ditch. If not, it must have swum the creek.

The mutation involving a single white dorsal head spot is manifested by three of the twelve specimens. The catalog numbers of these individuals are shown in Table 1, and the places of capture are shown in Figure 1. The sites of capture of all these pocket gophers are also on the south side of Sandy Creek. I have examined a series of 57 other study skins of *Geomys breviceps* from nine localities in Texas and one locality in Oklahoma. Only one skin from this series shows this mutation. This gopher was collected within the city limits of Colbert,

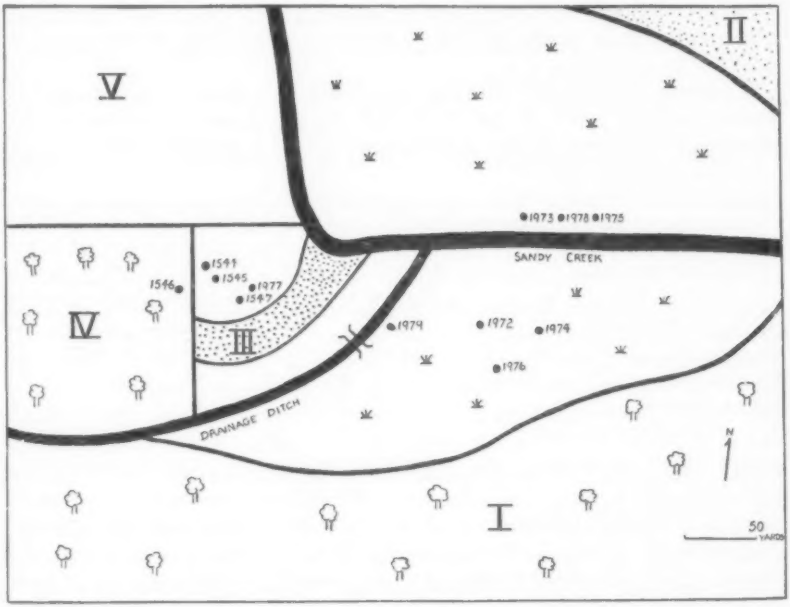

FIG. 1.—The distribution of *Geomys breviceps*, five miles southwest of Colbert, Bryan County, Oklahoma.

Oklahoma. It is possible that this mutation is fairly common in this region as very little collecting of *Geomys* has as yet been done in this part of Oklahoma.

The mutation involving the double head spot is present in seven of the twelve pocket gophers collected from this locality. Animals showing this mutation were taken on both sides of Sandy Creek and on both sides of the drainage ditch. This mutation was not present in any of the 57 other *Geomys breviceps* examined from Texas and Oklahoma.

The white spotting of the ventral surface is manifested in varying degrees, ranging from a white area around the mouth and axilla to an over-all whiteness of the ventral surface. This mutation is expressed in all twelve of the specimens

from this locality. The spotting of the ventral surface seems to be relatively common in this species of *Geomys*, since 46 of the 57 specimens examined from other areas exhibit this condition. However, the two specimens of *Geomys* from Colbert, Oklahoma, do not show this mutation.

Since three of the mutations present in this locality are not common elsewhere, and two of these three mutations are confined to areas south of Sandy Creek, it would seem that the creek and tight soils form fairly effective barriers. The expression of a comparatively large number of presumably recessive mutations in such a small partially isolated population would indicate that a considerable amount of inbreeding has occurred. This inbreeding in a small breeding population has resulted in the manifestation of recessive mutations which otherwise would not be expressed phenotypically in such a high percentage of the population.

A striking color-pattern mutation is apparent in a female pocket gopher collected October 15, 1949, by Dr. W. F. Blair and party, seven miles east of Lytle, Atascosa County, Texas. This mutation appears as an irregular pattern of white

TABLE 1.—*The distribution of four pelage color mutations in a series of pocket gophers collected five miles southwest of Colbert, Bryan County, Oklahoma*

MUTATIONS	CATALOG NUMBERS OF GOPHERS											
	1544	1545	1546	1547	1972	1973	1974	1975	1976	1977	1978	1979
Grizzled		X			X							
Dorsal head spot	X									X		X
Double head spot		X	X	X	X		X		X		X	
Ventral spotting	X	X	X	X	X	X	X	X	X	X	X	X

hairs on the dorsal and lateral surfaces of the head. On the left side of the head the white area is solid, extending from the nostrils posteriorly on the dorsal mid-line to a point even with the ear, and laterally forward from this point to a position below the eye on the dorsal edge of the external pocket, thence, in a straight line to the nostril. On the right side of the face there is a stripe of white, 15 mm. wide, which is continuous anteriorly with the larger white spot. This stripe extends from the nostrils laterally and posteriorly to a point halfway between the eye and ear. The entire white area is very sharply separated from the natural russet brown of the rest of the pelage. This specimen is the only one of fifteen female and thirteen male pocket gophers from this locality to exhibit such a condition. This mutation appears to be one that affects pigmentation, principally on the left side of the head, as the large white spot extends to approximately the mid-dorsal line of the head. This appears to be a different mutation from those described from the Oklahoma population. The Texas gopher was taken from a large, continuously-distributed population. Dispersal and outbreeding under these population conditions may account for the fact that only a single individual was found with this mutation expressed in the phenotype.

Summary.—Four apparently independent pelage color mutations are expressed in a partially isolated colony of pocket gophers (*Geomys breviceps*) from Bryan County, Oklahoma. Approximately eighteen individuals comprised the breeding population of this colony. It is believed that this partial isolation has resulted in a large amount of inbreeding. This inbreeding has resulted in the phenotypic expression of these presumably recessive mutations.

One pocket gopher collected in Atascosa County, Texas, from a continuously-distributed population exhibits a pelage color mutation which is restricted to the cephalic region.

I am indebted to Dr. W. F. Blair for aid in preparation of this paper, particularly the section dealing with the mutation from Atascosa County, Texas.

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WARM WEATHER FOODS OF THE RACCOON IN NEW YORK STATE

By W. J. Hamilton, Jr.

The food of the raccoon, *Procyon lotor lotor* (Linn.), has been studied by several investigators. Most reports on the dietary of this animal emphasize the late fall foods, since at this season material for study is more accessible to the investigator. Numbers may be obtained from hunters and trappers during the open season. Opportunity is limited for food study at other seasons except through the analyses of scats. Droppings do not give as good an index to the food as do stomach contents, since some foods are so thoroughly digested (earthworms, slugs) that the items either do not appear in fecal remains or are often so fragmentary that identification is impossible. A more nearly exact study of foods may thus be made by examination of stomach contents.

Dearborn (1932), Giles (1940), and Yeager and Rennels (1943) have listed the foods of raccoons through scat analyses. Giles (*op. cit.*) has made a seasonal food study of Iowa raccoons. Grimm and Roberts (1950) examined 41 fall and winter stomachs of late fall and winter-killed Pennsylvania animals. Prominent foods in the late summer and early fall included wild black cherry, pokeberry, and wild grapes. These authors report that two early June specimens were gorged with the nymphs and adults of seventeen-year cicadas, and add that in late June the raccoon feeds principally upon *Amelanchier*. Elsewhere (Hamilton, 1936), I have recorded the late fall and early winter foods of 127 New York raccoons. Summer food is based on the examination of 163 scats collected on the Montezuma Marsh of central New York (Hamilton, 1940). The present investigation supplements these earlier observations and, when combined with the other studies, presents a seasonal picture of the foods of New York raccoons.

Ninety-four animals containing food in sufficient quantity for analyses were collected from April through early October. Most of the specimens were taken from 1947 to 1950, although a few were collected in 1940. Of the total, two were

taken in April, ten in May, 13 in June, 11 in July, 17 in August, 32 in September, and nine in early October. I am particularly indebted to members of the New York Conservation Department for providing many specimens. State trappers, employed to reduce the rabid fox population, took numbers of raccoon, opossum, and other species in their sets. When these animals were too severely injured to warrant release, they were killed and the stomachs were removed and preserved for study. Raccoons trapped at the State Game Farm at Ithaca were also made available. The woodchuck control program at the Seneca Ordnance Depot, Romulus, New York, has resulted in a number of raccoon captures, all of which I have had opportunity to examine. Finally, a number of animals have been recovered from New York highways. These animals have provided a ready source for food and reproductive studies. The animals were collected primarily in central and western New York, although a number were taken in the Catskill Mountain area and the southern counties.

TABLE 1.—*Stomach contents of 94 raccoon taken from April through early October in New York State*

FOOD	PER CENT OF FREQUENCY	PER CENT OF TOTAL VOLUME
Fruits	51.1	37.9
Insects	40.4	8.2
Mammals	24.5	14.3
Grains	19.2	14.7
Earthworms	19.2	7.2
Amphibians	14.9	4.4
Vegetation	12.8	6.1
Reptile	9.5	3.0
Molluscs	4.3	1.9
Birds	3.2	1.5
Carrion	1.1	.6

Plant remains occurred in 74.5 per cent of the stomachs and constitute 58.7 per cent of the volume. Animal remains occurred in 67 per cent of the specimens examined and comprised 41.1 per cent by volume of all foods eaten (Table 1).

The seasonal foods eaten by the raccoon are, in general, reflected in the availability of the various food items. This is particularly pronounced with wild fruits, these constituting an important part of the food as the various species mature. Yeager and Elder (1945) have presented evidence that availability will determine the food of the raccoon. They point out that the simultaneous abundance of several presumably high quality foods may permit selective feeding. Tyson (1950), however, indicates that the raccoon may exercise a predilection for certain foods. In an examination of 29 animals taken in southwest Washington, no plant food had been taken, although fruits commonly eaten by the raccoon occurred in the area studied.

Plant foods.—When available, fruits appear to be the dominant food of New York raccoons, both in frequency and volume. *Prunus avium*, *P. virginiana*, and

P. serotina occurred in 28.7 per cent of the stomachs examined. Cultivated grapes had been eaten by approximately a third of the 32 September animals. A high raccoon population in the fall of 1950 took a measurable toll of grapes in some of the vineyards of western New York. Coons will virtually strip the grapes from a row of low vines in a few nights. In late June the raccoon feeds on wild strawberries, eating fruit, hull, and stem. Shadberries, *Amelanchier*, ripen soon after; two coons had eaten lavishly of these fruits. The berries of the silky cornel, *Cornus amomum*, are eaten in some quantity. September fruits include apple and ground cherry, *Physalis*.

Grains include corn, a favorite of the raccoon wherever it occurs. As soon as it ripens, the coon is busy tearing open the ripening ears and continues to feed on the hardened kernels late into the fall. Both April specimens contained some field corn. Before the heads mature, buckwheat and wheat are eaten. Green vegetation, principally grasses and less frequently clover, constitute a good share of the plant material eaten.

Animal foods.—Insects were eaten more frequently than other animals. Availability is again demonstrated in the increasing incidence of grasshoppers and crickets in the late summer and early fall stomachs. These orthopterans were found in 16 per cent of all stomachs examined. Tipulid larvae were present in 8.6 per cent of the animals. These crane fly larvae were eaten from May to October, suggesting that the raccoon may seek the waterways expressedly for these grubs. Beetles had been taken by 26 per cent of all the raccoons which contained insects. Carabids and scarabeids were the more important beetles eaten. Four animals had taken lepidopterous larvae, one stomach containing 30 large noctuid caterpillars. Single stomachs contained caddis fly cases with their included larvae and alder fly larvae, Sialidae. A single specimen contained numerous yellow jackets, *Vespa maculifrons*, and detritus from the wasp nest.

Of the mammalian remains, the meadow vole, *Microtus p. pennsylvanicus*, was the most important food, occurring in nine stomachs. Nest young of these voles occurred in two stomachs. Cottontails, *Sylvilagus floridanus mearnsi*, were taken from three raccoons. One coon had eaten three nest young of this rabbit. Gray squirrels, *Sciurus carolinensis leucotis*, had been eaten by two animals. The remains of a chipmunk, *Tamias striatus lysteri*, a star-nosed mole, *Condylura*, and a small muskrat, *Ondatra z. zibethica*, were recovered from single stomachs.

Amphibians had been eaten by 14 raccoons. Many of the frogs and salamanders eaten by the raccoon live well away from the waterways during the summer months. Leopard frogs, *Rana pipiens*, occurred in six stomachs; woodfrogs, *Rana sylvatica*, in five animals; *Plethodon cinereus* in three; *Ambystoma maculatum* in two; and *Hyla versicolor* and *Bufo americanus* once each. One animal had eaten three red-backed salamanders. A highway victim, taken between marshes that bordered the road, contained four woodfrogs, a leopard frog, a tree frog, *Hyla versicolor*, and a few corn kernels.

Snakes occurred in nine stomachs. These include three garter snakes, *Thamnophis o. ordinatus*, two red-bellied snakes, *Storeria occipitomaculata*, a rattlesnake, *Crotalus horridus*, and three undetermined colubrids. Remains of the rattlesnake,

consisting of the tail, part of the dorsum, and several ventral plates, had been eaten by a raccoon trapped at Fallsburg, New York, in early September, 1948. Whether the rattler was killed or eaten as carrion is problematical.

Molluscan remnants, particularly slugs, are not evident in scats, hence the added value of stomach analyses. Of the snails, *Triodopsis* and *Planorbis* are included in the food, while slugs, *Veroceras reticulatum*, had been eaten twice.

Remains of a meadowlark, a few breast feathers of a cock pheasant, and a trace of an unidentified fringillid comprise the bird remains.

No crayfish were found in the stomachs of the animals, a surprising fact when it is known that the raccoon often eats these crustaceans in large numbers.

Summary.—Stomach analyses of 94 New York raccoons taken from April through early October are discussed. Plant remains occurred in 74.5 per cent of the stomachs and constitute 58.7 per cent of the bulk. Animal remains were found in 67 per cent of the specimens and comprised 41.1 per cent by volume of all foods eaten. Fruits, grains, and green grasses constituted the plant foods, while insects, mammals, earthworms, amphibians, reptiles, molluscs, and birds were the principal animal items. No crayfish were recovered from the stomachs.

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MAMMALS OF THE OREGON CAVES AREA, JOSEPHINE COUNTY

By Aryan I. Roest

Apparently little work has been done on the mammalian life of the Siskiyou Mountains. Anderson and Grinnell (1903), Grinnell (1916), Kellogg (1916), and Mailliard (1921, 1923*a*, 1923*b*) have worked with both mammals and birds in the California Siskiyous, but the Oregon Siskiyous have remained untouched except for sporadic collecting. This is somewhat surprising, since it is in the Siskiyous that many boreal and austral forms, as well as animals from the coast ranges and the Cascade–Sierra Nevadas, are found together.

This report is the condensed result of field work in the vicinity of the Oregon Caves National Monument, a more complete discussion having been presented in a master's thesis at Oregon State College. The encouragement and advice of Dr. Kenneth L. Gordon are gratefully acknowledged. The assistance of Mr. Richard Rowley, a resident of the area since 1907, was of great value in this study, and Mr. Florenz Breitmayer, Jr., an employee of the Oregon Caves Company, also contributed useful information.

The area studied covered about four square miles in and around the national monument. Time in the field totalled about ninety days, in March, 1948, and from June to September, 1948.

The National Monument comprises an area of 480 acres, and is surrounded on all sides by the Oregon Caves State Game Refuge, in the Siskiyou National Forest. It is about twenty-four miles nearly due south of Grants Pass, Oregon, and about six miles north of the state line, in Josephine County.

The Siskiyou Mountains are the remains of an ancient, deeply dissected peneplain, resulting in a fairly level profile of ridgetops, separated by numerous steep-sided ravines or canyons. The caves are located at an elevation of 4000 feet, with two entrances opening on the north slope of a ridge running roughly east-west. This is known as Sand Ridge. East of the monument, along Sand Ridge, are three summits known as Mt. Elijah (6636 ft.), Lake Mountain (6663 ft.), and the Lookout (6636 ft.). These peaks form the southern perimeter of a small lake basin, containing Upper and Lower Biglow lakes. Both lakes are drained by Lake Creek, which runs northwestward and is separated from Cave Creek by a minor spur from Sand Ridge. Cave Creek, as its name indicates, has its source within the cave, and flows from the lower or main entrance. Lake and Cave creeks eventually join, continuing as Cave Creek to the Illinois River, which in turn empties into the Rogue River.

At the cave entrance are a group of buildings, including a hotel, gift shop, cabins, employees quarters, and a parking area, comprising the Oregon Caves Resort. A garbage dump is located about a mile north of the resort area, where the highway crosses Lake Creek.

Originally the caves had only two entrances near each other. Some years ago, however, a tunnel was blasted through 700 feet of marble to form the present exit, and a quarter mile exit trail leads back to the resort.

The weather at the caves is hot and dry during the summer months. In winter

the area is covered with snow which may reach a depth of six feet during a severe winter, but averages about three feet.

From approximately 2000 to 5500 feet elevation the vegetation is primarily an old Douglas fir (*Pseudotsuga taxifolia*) forest. In some areas seepages in the steep slopes provide sufficient moisture for small meadowlike areas. Such meadows include the Glade, above the caves on Sand Ridge, and the area around the Big Tree, a Douglas fir twelve and one-half feet in diameter, about a half mile east of the caves. Along the small streams, western yew (*Taxus brevifolia*), Port Orford cedar (*Chamaecyparis Lawsoniana*), and Oregon maple (*Acer macrophyllum*) are found in association with the Douglas fir, while on the drier, southerly-exposed slopes, yellow pine (*Pinus ponderosa*), tanbark oak (*Lithocarpus densiflora*), chinquapin (*Castanopsis chrysophylla*), and madrone (*Arbutus Menziesii*) are found with the commoner fir. Underbrush is scarce, and in the pure fir forest the ground is practically bare of living plants. A shrub layer, where present, is usually found in more open areas, and may be represented by a typical chaparral growth where the soil is thin, as over subsurface rocks.

Above an elevation of about 5500 feet, the dominant Douglas fir is replaced by mountain hemlock (*Tsuga Mertensiana*), with white-bark pine (*Pinus albicaulis*) and white fir (*Abies concolor*) as the associated species. Around the lakes are large herbaceous meadow areas. The ridges, especially their southern exposures, are dry and rocky, and support a low chaparral growth.

Because it is illegal to collect specimens in a national monument, most work was done by direct observation. Some specimens were taken, either from outside the monument or as animals killed within it by accident. Identification is consequently to species only, except in such fairly obvious cases as the blacktail deer. All specimens taken are now in the Oregon State College Museum of Natural History, unless otherwise indicated. Plant identification follows Peck (1941).

ACCOUNTS OF SPECIES

Sorex vagrans Baird. Vagrant shrew.—Two male shrews of this species were taken during the summer, July 9 and 27, 1948. Both came from open or forest areas, near rock outcrops, on north to northwest-facing slopes.

Myotis yumanensis (H. Allen). Yuma bat.—Two male specimens were obtained on August 12 and 20, 1948, respectively. The first came from the basement of the hotel, the second from the exit tunnel.

Myotis evotis (H. Allen). Big-eared bat.—A male of this species was killed July 2, 1948, in the hotel dining room.

Myotis thysanodes Miller. Fringe-tailed bat.—A male with testes descended was caught in the exit tunnel September 4, 1948. This specimen has been sent to Dr. Seth Benson, at the University of California. There are only two previous records of this species from Oregon, to my knowledge, both taken in Tillamook County by Mr. Alex Walker, on September 13, 1928, and August 3, 1940.

Corynorhinus rafinesquei (Lesson). Long-eared bat.—On August 26, 1948, a male with testes descended was killed in the basement of the hotel.

Lasionycteris noctivagans (Le Conte). Silver-haired bat.—Jewett (1926) reports that this species was abundant at the caves, but no sign of it was found in 1948.

Ursus americanus Pallas. Black bear.—Bears were seen throughout the summer, especially at the garbage dump. Both black and brown phases were observed in a ratio of about

3:2. Although seen only in the timber, tracks showed that they also traveled the ridge-tops.

Bassariscus astutus raptor (Baird). Ring-tailed cat.—Although absent in recent years, Mr. Rowley reported that these animals had occurred in the resort area in the past, and that he had tamed three of them one winter.

Martes caurina Merriam. Marten.—Forest Service reports indicate that martens are fairly abundant, but Mr. Rowley stated that they were not common, although still present in the higher parts of the mountains.

Martes pennanti (Erxleben). Fisher.—The 1939 Forest Service report states that this species is either very rare or no longer occurs here.

Mustela frenata Lichtenstein. Long-tailed weasel.—Weasels have been seen occasionally in the vicinity of the resort, according to Mr. Breitmayer.

Mustela vison Schreber. Mink.—Mr. Rowley reported that mink were formerly trapped in small numbers along the streams.

Spilogale gracilis Merriam. Spotted skunk.—In early June a spotted skunk was seen near the steps of the gift shop. Another (or the same one) was noted in a woodpile in the hotel basement during July.

Vulpes fulva (Desmarest). Red fox.—Mr. Rowley says red foxes occur in the area, but are not common. Walling (1884) reported that silver foxes were occasionally trapped in the Siskiyous.

Canis latrans Say. Coyote.—Several times during the summer the night clerk in the hotel saw coyotes around the garbage cans at the kitchen entrance. Two were seen on September 9, 1948, at 3:30 A.M. Tracks and droppings were frequently seen along Sand Ridge. According to the Forest Service report for 1945, coyotes killed a beaver at Upper Biglow Lake in that year. Steel (1890) reported hearing a coyote at the caves in 1888.

Canis lupus fuscus Richardson. Wolf.—According to Mr. Rowley, a pack of about nine wolves roamed the area between 1910 and 1915. To his knowledge, the last wolves seen were a pack of seven, observed crossing the road near Williams by Dr. Loughridge of Grants Pass, in 1923. In the Oregon State Game Commission Biennial reports, one wolf was turned in for bounty payments in Jackson County, adjacent to the east, almost every year from 1920 to 1932. In the 1933–1934 period, twelve were reported bountied, but none since that date. Wolves were reported seen in the high Siskiyous by foresters or cattlemen in the 1934, 1937, and 1938 Forest Service reports.

Felis concolor True. Mountain lion.—A lion was seen crossing the highway a few miles below the caves three times during 1948. These animals are often hunted with dogs by local residents.

Lynx rufus Schreber. Bobcat.—Fresh bobcat tracks were seen in the snow near the resort in January and December, 1948, by Mr. Breitmayer. The form in the caves area may be an intergrade between *californicus* and *fasciatus*.

Citellus beecheyi douglasi (Richardson). Beechey ground squirrel.—Several "graydiggers" maintain themselves in the resort area by begging for peanuts. They occur also along the highway, but nowhere else.

Citellus lateralis trinitatis (Merriam). Mantled ground squirrel.—This species was observed in the resort area, at the garbage dump, and along the slopes and ridge just south of Upper Biglow Lake. Two males and a female were picked up as fresh road kills from the parking area on June 21, July 1, and August 23, 1948, respectively. The female had very thin fur, pale in color. Young animals were first observed on July 13.

Eutamias amoenus ochraceous Howell. Yellow pine chipmunk.—A male and a female were collected August 13, 1948, from the ridge near Mt. Elijah. The male was in the bright summer pelage, but the female was still in the gray winter fur. Her nipples indicated recent nursing.

Eutamias townsendi siskiyou Howell. Townsend chipmunk.—Observed throughout the Douglas fir forest, and at the resort. A female collected August 19, 1948, showed evidence of recent nursing.

Tamiasciurus douglasi Bachman. Chickaree.—Seen and heard throughout the Douglas fir. An adult male collected August 4, 1948, at the garbage dump showed the beginning of a molt at the shoulders. Some of those seen had white undersides, some yellowish or orange, apparently indicating an intergrading form.

On June 21, two were observed in a courtship chase, running spirally around a small fir trunk for several minutes. Finally the female stopped, clinging to the tree with head pointed upward. The male then mounted from below, dog fashion, holding tightly to her and not to the tree.

One individual, which ranged in the trees near the hotel, was twice observed to chase after young mantled ground squirrels on the ground, catch them, and kill them by rolling them over and over, biting at throat and head.

Sciurus griseus Ord. Western gray squirrel.—This form occasionally wanders up to the caves from the valley. Two were seen at the parking area in July.

Glaucomys sabrinus Shaw. Flying squirrel.—On August 6, 1948, a tourist brought in the terminal two-thirds of the tail of a flying squirrel which had been found on a trail near the Big Tree.

Castor canadensis Kuhl. Beaver.—The Forest Service planted eight beaver in Upper Biglow Lake in 1935. The colony still exists, but has not spread, apparently due to unfavorable food conditions in the surrounding country. The population is now estimated at about twenty individuals, and they have constructed one large lodge, two small dams, and several bank houses. Food now includes manzanita twigs and water lily stalks. The willows which formerly grew along the lake shore have been practically exterminated.

Peromyscus maniculatus (Wagner). White-footed mouse.—A very common species about the resort and in the surrounding forest, being found up to the summit of Lake Mountain. Judging from published range maps, the form at the cave is probably an intergrade between *gambeli* and *rubidus*. Mice are frequently seen inside the cave, but if resident there, the only food available to them would be the candy wrappers dropped by the tourists. Three specimens were taken through the summer. On July 15, 1948, two young mice, furred, but with eyes still closed, were found on the road in front of the hotel.

Neotoma fuscipes fuscipes (Baird). Dusky-footed woodrat.—A young female was caught August 15, 1948, in the gift shop. Others were often seen and heard in all the resort buildings. Nests of rats were found in the attic of the guide's quarters, between the ceiling beams. They resembled bird nests in that they were built of leaves and sticks, and each had a shallow depression six inches in diameter, lined with grass.

Neotoma cinerea occidentalis (Baird). Bushy-tailed woodrat.—One specimen, a male, was collected September 14, 1948, at the edge of a small stream west of the resort area. Another was seen running along a steam pipe in the hotel basement.

Phenacomys longicaudus True. Red tree mouse.—A juvenile male was killed in the guide's quarters August 17, 1948. A few white hairs were present at the tip of the tail.

Clethrionomys californicus (Merriam). Red-backed mouse.—On August 6, 1948, an adult of this species was seen in bright sunlight as it carried a hairless young across the trail from the cave exit, holding it by the abdomen, its feet pointing upward. The adult was observed from about six feet away, and the dark gray coloration and reddish back were readily seen for several seconds.

Ondatra zibethica (Linnaeus). Muskrat.—On October 15, 1948, Mr. Breitmayer killed a muskrat in the small pool just outside the hotel. It was probably a wanderer from the valley, where this species has been introduced.

Aplodontia rufa (Rafinesque). Mountain beaver.—Burrows of mountain beaver were found at the Glade, the Big Tree, and in the ravine above the resort. A half-grown specimen was found in the Ghost Chamber of the cave, 800 feet from the nearest known opening. It had been dead for several days and mice had chewed parts of it, but the skull was saved.

Zapus trinotatus Rhoads. Jumping mouse.—Mice of this species were seen three times, twice in the employee's quarters and once along Cave Creek below the hotel.

Erethizon dorsatum (Linnaeus). Porcupine.—A porcupine was seen early in June along

a trail west of the resort. Various reports indicate that the porcupine occurs, but is never common.

Lepus americanus Erxleben. Snowshoe Hare.—Hares were seen several times during the summer at the cave exit, under the cabins above the gift shop, and along the trail above the guide's quarters.

Sylvilagus bachmani (Waterhouse). Brush rabbit.—On July 3, 1948, a small dark rabbit, probably of this species, was seen in a madrone and rhododendron thicket above the parking area.

Cervus canadensis roosevelti Merriam. Roosevelt elk.—Walling (1884) says that in earlier days elk were common in the Siskiyous, but by 1884 had been much reduced and confined to the more inaccessible parts of the mountains. At present they are restricted more to the coast, but Forest Service reports indicate they occasionally drift inland.

Odocoileus hemionus columbianus (Richardson). Blacktail deer.—The Forest Service feels this area is one of the best in the Siskiyou National Forest for deer, and they are seen fairly commonly at all elevations. The largest single group, composed of nine deer, was seen March 18, 1948, behind the hotel. One old buck, identified by a slit ear, has visited the resort area for at least thirteen years.

DISCUSSION

As has been pointed out in the introductory paragraph, the Siskiyou Mountains are a region where representatives from several faunal areas mingle. In order to facilitate a study of this mixture in the area covered, it must first be broken down into its component parts. As a guide in such an analysis, which appears below, the examples of Merriam (1892) and Gordon (1947) have been followed.

Thirty-nine species have been mentioned as occurring at the caves, but only thirty-two can be considered in this analysis. The five bats are here disregarded due to insufficient knowledge of their ranges or habitat requirements. Beaver and muskrat are both introduced species, and hence must be discarded for this analysis.

Boreal and austral elements are both noticeably present at the caves. In addition, it is clear that three areas have been the immediate sources of much of the fauna. These are the coast ranges, the Cascade–Sierra Nevada system, and the California valley. Three forms may be considered endemic, at least subspecifically. A fifth group is composed of wide ranging forms whose immediate origins cannot be traced. The tropical element is represented by the porcupine, having as its immediate origin the Cascade–Sierra Nevadas. This analysis is outlined below.

Coast Range (15.6 per cent).
- Boreal element: *Sorex*, *Mustela frenata*, *Phenacomys*, *Cervus*.
- Austral element: *Odocoileus*.

Cascade–Sierra Nevada (28.1 per cent).
- Boreal element: *Martes caurina*, *Martes pennanti*, *Vulpes*, *Tamiasciurus*, *Glaucomys*, *Clethrionomys*, *Aplodontia*, *Zapus*, *Lepus*.
- Austral element: (none).
- Tropical element: *Erethizon*.

California valley (15.6 per cent).

Boreal element: (none).
Austral element: *Bassariscus, Citellus beecheyi, Sciurus, Neotoma fuscipes, Sylvilagus.*

Endemic (subspecies level) (9.4 per cent).
Boreal element: *Eutamias amoenus, Eutamias townsendi.*
Austral element: *Citellus lateralis.*

Undetermined origin (28.1 per cent).
Boreal element: *Ursus, Mustela vison, Canis latrans, Canis lupus, Felis, Lynx.*
Austral element: *Spilogale, Peromyscus, Neotoma cinerea.*

Totals.
Boreal element: 65.5 per cent.
Austral element: 31.3 per cent.
Tropical element: 3.1 per cent.

As can be seen, the mammals at the caves are largely boreal in origin, and the Cascade-Sierra Nevada system has been the immediate source of most forms. Strong elements from both the coast ranges and the California valley are present, however. This mixture of elements is no doubt due to the variety of habitats available in the caves area, including mature forest, moist streamside forest, meadow areas, and dry chaparral. The interconnecting system of mountain ranges forming the Klamath mountain system has played an important part in providing travel routes for montane forms.

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GENERAL NOTES

A NEW JUMPING MOUSE FROM THE UPPER PLIOCENE OF KANSAS

The University of Michigan Museum of Paleontology field party spent the month of July, 1950, working an Upper Pliocene deposit in Meade County, Kansas. The party consisted of Thomas M. Oelrich, Dwight W. Taylor, James Rogers, Thomas Sparrow, and Claude W. Hibbard.

Among the material recovered is the right ramus of a jumping mouse. This is the first record of the family Zapodidae from the Upper Pliocene of North America. It adds another mammal to the well-known Rexroad fauna. The ramus differs from that of other known species of *Zapus*.

Zapus rinkeri sp. nov.

Holotype.—No. 27036, University of Michigan, Museum of Paleontology, right ramus bearing M_1–M_3, adult. Collected in the summer of 1950 by the University of Michigan Museum of Paleontology, field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, sec. 35, T. 34S, R. 30W, XI Ranch, Meade County, Kansas.

Diagnosis.—A jumping mouse with a more massive ramus and a larger M_3 than is found in Recent species of *Zapus*. The external reentrant valleys of the teeth are broader and not as constricted as in the Recent forms of *Zapus*.

Description of holotype.—The holotype is a right ramus of a middle-age adult (Fig. 1b and c). The tip of the incisor and the ascending ramus are missing. The entire ramus is more massive than in any known Recent form. The diastemal region is flattened and broad transversely. Therefore, the mental foramen appears to rest more nearly on the dorsal surface of the diastemal region than on the labial side of the ramus. The incisor has a greater transverse width than in the Recent forms, and is extended well into the ascending ramus.

The anteroposterior length of the occlusal surface of M_1–M_3 is 4.3 mm. This tooth-row length was observed in *Zapus princeps* Allen and *Zapus trinotatus* Rhoads. *Zapus rinkeri* is distinguished by the greater transverse width of M_1 and the broad and shallow external reentrant valley of M_1 and M_2. The M_1 of *Zapus rinkeri* has the same occlusal length as M_2. The anterior part of M_1 is nearly as wide as the posterior part. The teeth do not seem to be shorter crowned than the teeth of Recent forms. The internal reentrant enamel valleys do not extend as deep vertically into the side of the crown of the teeth as they do in the teeth of Recent forms of *Zapus*. M_2 possesses a greater anterotransverse width and a broader external reentrant valley than in Recent forms. M_3 has a greater anteroposterior length than that tooth in the Recent species of *Zapus*. The external reentrant valley is broad but shallow.

The occlusal enamel pattern of the teeth can be approximately duplicated in a series of Recent *Zapus*.

The species is named for the late Dr. Glen Clark Rinker of Hamilton, Kansas, who has contributed to our knowledge of Recent vertebrates for the past 50 years and who was a member, a number of times, of the University of Kansas paleontological field parties.

Remarks.—The specimen has been assigned to the genus *Zapus* instead of *Napaeozapus* because of its generalized enamel pattern which is like that of *Zapus*. The enamel pattern of *Napaeozapus* is more complicated and the reentrant valleys are more compressed than in *Zapus*.

Zapus rinkeri is part of the well-known Rexroad fauna. For a discussion of associated forms see Hibbard (Contrib. Mus. Paleontol., Univ. Michigan, vol. VIII, no. 6, pp. 112–192, 5 pls., 23 figs., 1950).

The family Zapodidae is poorly known from Cenozoic deposits in North America. The earliest form of the Zapodinae known in North America is *Pliozapus solus* Wilson from the Middle Pliocene of Smiths Valley, Nevada. *Zapus rinkeri* cannot be considered as bridging the gap between *Pliozapus* and *Zapus* though it does possess the broader and shallower external reentrant valleys of the lower molars which occur in *Pliozapus*, but the teeth are higher crowned and possess a dental pattern of *Zapus*. The genus *Zapus* is poorly known from the Pleistocene deposits of North America. *Zapus burti* Hibbard is known only from

FIG. 1.—(a) Occlusal view, right M_1–M_3, of *Zapus burti* Hibbard; holotype, KU No. 6152. (b and c) Occlusal view of RM_1–M_3, and lateral view of right ramus of *Zapus rinkeri* sp. nov.; holotype UMMP No. 27036. All × 8. Drawing by Jane S. Mengel.

two rami found associated with the Borchers fauna, which was recovered from the Crooked Creek formation, Middle Pleistocene, Meade County, Kansas.

Zapus rinkeri is distinguished from *Zapus burti* Hibbard (Fig. 1a) by its larger size and broader molars. The anteroposterior crown length of M_1–M_3 of *Zapus burti* is 3.8 mm. The two species have in common a broad shallow external reentrant valley on M_1 and M_2. *Zapus burti* possesses only two internal reentrant valleys posterior to the anterior loop on M_1, though the teeth are those of a young adult. This is in contrast to the dental pattern of *Zapus rinkeri* where the teeth show a greater amount of wear and the third posterior internal reentrant valley is evident from the lingual side of M_1.

Gidley and Gazin (U. S. Nat. Mus. Bull. 171, 1938) reported *Zapus* sp. based on part of a right ramus from the Cumberland Cave fauna of Maryland, where it was taken in association with *Napaeozapus* cf. *insignis* (Miller). Cope reported *Zapus hudsonius*? from the Port Kennedy Cave fauna (Pleistocene) of Pennsylvania.

I am grateful to Dr. Robert W. Wilson of the University of Kansas, Museum of Natural History, for permission to restudy and refigure the holotype of *Zapus burti*. The illustrations of this paper were made possible by the financial support of the Faculty Research Fund of the University of Michigan.—CLAUDE W. HIBBARD, *University of Michigan, Department of Geology, Ann Arbor, Michigan.* *Received December 13, 1950.*

A NEW *MICROTUS* FROM THE WESTERN ARCTIC OF CANADA

The summer of 1947 was spent by the author on the Mackenzie Delta region of the Northwest Territories of Canada. There, incidental to other biological studies, a small collection of mammals was secured. Although well north of the Arctic Circle, the southern three-fourths of the Delta is in the forested part of the Arctic. Throughout this three-fourths the most abundant microtine rodent was *Microtus pennsylvanicus drummondi*. No trapping was undertaken in the tundra habitat on the mainland of the northern part of the Delta, but earlier biological work in the vicinity of Tuk-toy-ak-tuk (Port Brabant of some maps) failed to take *Microtus pennsylvanicus*.

At Kidluit Bay on the eastern extremity of Richards Island, however, a *Microtus* was taken that differed so markedly in color and in size from *M. p. drummondi* forty miles up river that from the capture of the first specimen there was no doubt of the distinctness of this population.

Careful study of the Richards Island series in comparison with series of *M. p. drummondi* from many localities and of *M. p. aphorodemus* from the western shores of Hudson Bay have confirmed the distinctness of the island population. It is proposed to name this:

Microtus pennsylvanicus arcticus ssp. nov.

Type.—Adult male, number 2329, Museum of Zoology, University of British Columbia taken July 28, 1947, at Kidluit Bay, northeast corner of Richards Island, 133°49′ west longitude and 69°31′ north latitude, Northwest Territories, Canada, by I. McT. Cowan.

Distribution.—Known only from the type locality.

Diagnosis.—Size large, similar in size to *Microtus pennsylvanicus aphorodemus*, but with tail averaging actually and relatively shorter, skull narrower across the zygomatic arches (P = .05–.03) and color much paler and grayer. The darkest specimen in the type series is approximately equal to the palest in a series of 12 topotypes of *M. p. ahorodemus*. The color of paler examples approximates that of *Microtus montanus canescens*.

M. p. arcticus differs from *M. p. drummondi* to statistically significant degree (P = .01) in body length, tail length, condylobasal length, zygomatic width, greatest length of nasals, and greatest width of nasals. In each of these features *arcticus* is larger than *drummondi*. The gray, rather than brown, color is equally distinctive of *arcticus* in comparison with *drummondi*.

Measurements.—External dimensions of 6 specimens of *arcticus* including both sexes have the following means and ranges: total length, 172 mm. ± 1.28 (168–180); tail, 44.5 ± .780 (40–48); hind foot, 19.6 ± .153 (19–20). Skull measurements are as follows: basal length, 27.4 ± .253 (26.7–28.1); zygomatic width, 15.5 ± .120 (15.2–16.1); greatest length of nasals, 7.6 ± .077 (7.3–7.8); greatest width of nasals, 3.3 ± .053 (3.0–3.5). Other measured cranial features in the new race are the same as corresponding features in *aphorodemus* and *drummondi*.

A series of 7 *drummondi* from Aklavik, N.W.T., has the following measurements: total length, 153 ± 1.50 (147–157); tail, 35.4 ± 1.09 (31–40); hind foot, 19.4 ± .567 (17–21); basal length, 26.2 ± .253 (25.2–27.1); zygomatic width, 15.0 ± .148 (14.2–15.4); mastoid breadth between squamosal fenestrae, 11.3 ± .0834 (6.7–7.5); greatest width of nasals, 2.9 ± .065 (2.6–3.1); greatest width of rostrum, 4.8 ± .056 (4.5–5.0); length of upper tooth row, 6.3 ± .136 (5.8–6.5).

Remarks.—Cranial features and tooth crown pattern clearly place the new race with the species *Microtus pennsylvanicus*. The great difference in dimensions of body and skull parts and the distinctive coloration provide greater differences than exist between almost any other pair of adjacent subspecies in this species. It seems probable that *drummondi* stock gave rise to *arcticus* as Richards Island lies between major branches of the Mackenzie River at its mouth and is exposed to quantities of flotsam from up river. *M. p. drummondi*, the only race of the species inhabiting the shores of the Mackenzie, has not been taken north of the tree line in the western Arctic and this gap of perhaps 40 miles, together with what-

ever barrier effect is offered by the one-half mile to one mile width of the river, have apparently effectively isolated the Richards Island population.

In size, *arcticus* resembles *aphorodemus*, the other tundra-inhabiting race of the species, but is geographically separated from it by many hundreds of miles of tundra in which the species is unknown. The similarity in size may be chance, or it may be a parallel response to tundra conditions.

I am indebted to Dr. H. H. T. Jackson, United States National Museum, and to Mr. Earl Godfrey, National Museum of Canada, for the loan of specimens of *aphorodemus*; also to W. E. Stevens for field assistance.—I. McTAGGART COWAN, *Dept. of Zoology, Univ. of British Columbia, Vancouver, B. C.* *Received April 12, 1951.*

KEEPING BRITISH SHREWS IN CAPTIVITY

Pearson (Jour. Mamm., 31: 351–52, 1950), publishes a welcome note on keeping shrews in captivity. The widespread belief in the "delicate" nature of shrews originated mainly in the writings of the early British naturalists at the turn of the century. Dagleish (The Zoologist, ser. 4, 8: 425, 1904), for example, writes: "They are very sensitive, and easily killed from shock as I can vouch. Wishing one year to procure living specimens, I set the old fashioned wooden mouse traps, but always found the shrews dead in them, and *suppose they died of pure fright.*" Lionel Adams (Wild Life, 1 (2): 82–87, 1913) reports: "*It is an indisputable fact that shrews are very easily frightened to death.* I have myself found them dead beside traps which had snapped without touching them, while Mr. English has recorded more than one instance of a sudden noise proving fatal to his captives."

Pearson suggests that these ideas may have originated in observations on exceptional individuals. This may be the case, as one occasionally finds that a mouse or vole will die when handled. I consider it more probable, however, that they arose from a lack of appreciation of the food requirements of shrews, coupled with observations on semi-starved individuals. This is supported by the remarks of Barrett-Hamilton (A History of British Mammals, 1910): "Anyone who has watched the gait of shrews of any species at close quarters, as in captivity, through glass, cannot fail to have been struck with the extreme feebleness displayed. They totter in every movement, exactly as if they were suffering badly from rickets; their legs barely support their weight, and they continually stumble over the slightest obstruction such as a small bit of moss or grass, so that in the case of a freshly caught individual one can hardly persuade oneself that one of its legs is not broken." The rapid and energetic movements of a healthy shrew cannot be described in such terms, but a semi-starved shrew usually suffers partial paralysis of the forelimbs, when its movements correspond exactly to this description. Many individuals in the last stages of starvation and exhaustion react to sudden disturbance or handling with a final burst of apparently normal activity. In a matter of seconds this last effort terminates abruptly in the animal's collapse and almost instant death. If starvation has proceeded so far that the shrew is unable to take proffered food, it may sometimes be revived sufficiently to feed by gently forcing the ingestion of a few drops of a warm strong solution of Glucose-D (a patent preparation consisting of pure glucose with added vitamin-D and mineral salts). If starvation has proceeded too far, the handling involved in forcing the pipette into the animal's mouth brings about its death. The mute rapid collapse in the hand, of a frantically active shrew, would provide convincing evidence of incipient "weakness" if one were not familiar with the lack of effect of similar or more strenuous handling on well-fed individuals.

Pearson reports success in converting *Blarina brevicauda*, *Sorex cinereus*, *S. ornatus*, *S. vagrans*, *S. pacificus*, *S. trowbridgei*, *S. palustris*, and *Cryptotis* to a diet of meat, liver, and cereal. *Neomys fodiens*, *Sorex araneus*, and *S. minutus* may be maintained on a similar diet, but in England, under rationing, meat and liver prove to be more difficult to obtain than invertebrates! My laboratory stocks were kept on a diet of earthworms and oats, supplemented largely by mouse and vole corpses. Initial failure proved to be due to lack of grain. It is necessary to supply ample drinking water. On one occasion, when short of suitable food, I offered fish, which was eagerly devoured. The food should preferably be

given in small quantities at frequent intervals. If the day's rations are given at the first feeding, the shrew may gorge itself in the morning and starve in the afternoon. *Sorex araneus* and *S. minutus* require their own weight of earthworms or meat daily, but *Neomys fodiens* needs proportionately less. A supply of grain should always be available. Lactating females of *Sorex araneus* devour more than twice their weight of food daily. The regular supply of excessive food causes an initial rapid increase in body weight. In captivity sexually immature individuals which would normally reach adult weight in about four months, do so in as many weeks (Table 1). Dissection shows, however, that the increase is not due to accelerated development, but to the deposition of fat, chiefly about the neck and shoulders.

For laboratory accommodation Pearson uses glass-sided boxes littered with wood shavings, and provides a nest jar. Similarly, I use metal or glass-sided boxes, a foot square and open at the top, but either strew the floor with hay or first tamp down a few inches of soil. The shrew quickly builds itself a nest from the hay and later incorporates any fur or skin debris. The soil, if changed occasionally, in addition to allowing normal burrowing activity, provides small organisms. *Sorex araneus* and *Neomys fodiens* burrow almost incessantly, but *Sorex minutus* shows less inclination. These three shrews defaecate almost every minute while awake, but always select a principal lavatory well away from the nest, which is itself kept quite clean, and can be transferred intact when the cage is cleaned. Out of the breeding season more than one animal can be confined together providing the cage is large enough to preclude too frequent accidental contact during searching. Relatively vast quantities

TABLE 1.—*Body weights of S. araneus, in grams*

AT CAPTURE	30 DAYS AFTER CAPTURE	PER CENT INCREASE AFTER 30 DAYS	60 DAYS AFTER CAPTURE	PER CENT INCREASE AFTER 60 DAYS
6.4	8.3	29.7	—	—
6.3	9.0	42.8	10.1	60.3
7.1	9.4	32.4	11.0	54.9

of food must be supplied, cannibalism occurs only in the absence of alternative food.—PETER CROWCROFT, *Bureau of Animal Population, Department of Zoological Field Studies, Oxford University.* *Received January 27, 1951.*

LIVE-TRAPPING BRITISH SHREWS

The predisposition of shrews to enter and explore every encountered crevice and opening considerably simplifies trapping procedure. Chitty and Kempson (Ecol., 30: 536–542, 1949), in their description of the Longworth trap, include *Sorex araneus* among species exhibiting "new object reaction," manifested in initial reluctance to enter traps. With such species the largest catch for a given expenditure of labour is obtained if the animals have been prebaited, i.e. allowed to become familiar with open but unset traps. Contrary to this view I find that *Sorex araneus* and *S. minutus* immediately investigate new objects, except when startled by their own movements reflected in bright surfaces. Trapping figures, using the Longworth live-trap, show a tendency to fall off with progressive captures and removals, as experienced when using unbaited breakback traps (Table 1).

When trapping for shrews it thus seems best to trap without prebaiting. Immediate trapping yields the largest catch for labour expended, and allows less preempting of traps by associated species exhibiting "new object reaction." The Longworth trap is especially suitable for shrews as it is operated by a treadle of adjustable sensitivity down to 1.5 grams. It is necessary to affix a cover to the top opening of the trigger-mechanism cowling to prevent the escape of *Sorex minutus*, weighing about 3 grams. The cover should be riveted so that it can be swung aside to facilitate cleaning, or to provide an escape route for this species when trapping for others. A little hay or dry grass in the nest box provides insulation. No

bait is necessary, but the traps should be visited every two hours if live animals are wanted. When removing *Sorex araneus* and *S. minutus* from a population comprising, in addition, *Microtus agrestis*, *Clethrionomys glareolus*, and *Apodemus sylvaticus*, advantage may be taken of the shrews' ability to pass through narrow apertures by virtue of their narrow skulls and lack of pubic symphysis. A metal partition or "excluder" perforated by a hole $\frac{1}{2}$ inch in diameter is fixed in the trap tunnel between the door and the treadle. This prevents the ingress of all the rodents except an occasional juvenile. A true comparison of shrew density in various habitats in thus obtainable irrespective of the density of the rodents present. If the diameter of the hole is reduced to $\frac{3}{8}$ inch *Sorex araneus* is excluded and *S. minutus* selected from the population. No time and labour are wasted in ejecting unwanted animals and resetting. The method is limited in scope, but may prove useful to other workers wishing to study the smallest of the small mammals on an area.

Shrews may be caught, when suitable traps are not available, by sinking canisters or buckets at least 9 inches deep, flush with the ground. I have found this a useful sampling device requiring the minimum of attention. As they are extremely poor sighted (or preoccupied), shrews are more likely to blunder into pit traps than are their more wary asso-

TABLE 1.—*Trapping record of shrews*

DATE	NUMBER OF TRAPS	CATCH							
		1	2	3	4	5	6	7	8
Dec.	40	6	1	0	1	0	1	—*	—
Jan.	50	3	1	0	0	0	0	0	—
Mar.	80	4	4	4	2	4	—	—	—
Apr.	78	5	4	1	0	—	—	—	—
Apr.	48	1	1	1	—	—	—	—	—
May	31	7	4	0	0	2	0	0	0
May	37	0	0	3	4	0	2	3	0

* No catch attempted.

ciates.—PETER CROWCROFT, *Bureau of Animal Population, Department of Zoological Field Studies, Oxford University. Received January 27, 1951.*

OBSERVATIONS ON NEW ENGLAND BOBCATS

The typical habitat of the bobcat in New England is forested land that offers good ground cover, such as mountain laurel, and hilly land with rocky ledges. Bobcat tracks were observed in all forest types, but a mixture of hardwoods and conifers appears to be the preferred type. Concerning the habitat of the bobcat in northeastern United States, Hamilton (Mammals of Eastern United States, 1943) says, "The bobcat is adaptable, changing its way of life as civilization modifies the environment. It does not depend on the deep forest, as the lynx does, but rather makes its home in the swamps, wooded districts, and mountain regions, often close to farm lands."

Trappers from New Hampshire and Maine report that dense swamps which have a good population of varying hares seem to be the typical habitat of the bobcat in these states. I found bobcat tracks, in Massachusetts, in white pine plantations, mixed hardwoods, swamps, and second growth surrounded by agricultural lands.

Field observations were limited to times when there was good tracking snow. Most of them were made in the southwestern part of Massachusetts where a large population of bobcats occurs.

According to Seton (Lives, 1929) and others, the bobcat depends mainly on its sharp eyesight to detect its prey. A cat was trapped in western Massachusetts in a dirt-hole set baited with a small piece of vension and a lure of catnip and cat urine. This suggests that the cat

does have some sense of smell. The following kills were observed by the writer: grouse (one), varying hare (one), cottontail (three), porcupine (one), and deer (a questionable one).

The majority of the bobcat tracks usually crossed runways or trails of varying hares and cottontails. The cats appear to follow these trails commonly, but unless the hare or cottontail is jumped and caught immediately, pursuit is not extreme. Only one varying hare kill was observed. The cat stalked the hare near a patch of laurel and caught it after a chase of 20 yards. As evidenced in all cases, stalking shows clearly in the snow through the evident drag marks of the bobcat.

Bobcats seldom pass up the chance to follow and stalk cottontails along their runways. Two kills on runways were found in southwestern Massachusetts; in both cases the cat caught the rabbits within three to ten yards. Remains of these kills were just bits of pelage and spots of blood. Another kill was observed in the township of Leverett, Massachusetts, where a bobcat lay by a cottontail's burrow and made its kill, leaving just a small piece of the rabbit's viscera and a spot of blood.

Fourteen bobcat trails which I followed suggest that the animals travel about two to five miles each night in their hunting forays. There was no evidence of diurnal activity except when chased by dogs. Rollings (Jour. Wildlife Mgt., 9: 131–45, 1945), in Minnesota, tracking cats from rest shelters left at night to those entered the next morning, found that the distance varied from three to seven miles, and averaged five and one-half miles. Rollings suggests that these distances might have been shorter had food been more abundant. Marston (Jour. Wildlife Mgt., 6: 328–37, 1942) stated the following concerning the range of a Maine bobcat: "Within a month this individual had been located at three different points forming a triangle the sides of which totalled about 18 miles. The smallest circle to include all three points had a circumference of nearly 23 miles. If, as later suggested, cats travel in circles, the figures indicate that this cat covered a territory of more than 40 square miles."

D. T. Ford and a group of cat hunters pursued a bobcat with hounds for five consecutive days in February, 1947. This cat was ledged each day and the following morning pursued again. The circumference of the circle of travel taken by the cat is estimated at 18 miles as plotted on topographical maps. This does not include the small circles the cat took before ledging up. As cats run continuously in circles when pursued by hounds, Ford estimated that this cat ran, in the five days, approximately 40 to 45 miles. On the fifth day the cat was treed and killed. This male cat weighed 18 pounds and apparently was in poor physical condition after the chase, probably through lack of food. Ford also thought that the cat knew the country which he traveled as it found the dens easily.

Field observations in the vicinity of the Quabbin Reservoir, Massachusetts, where there is a high population of porcupines, showed that, in late winter and early spring, places that harbor porcupines, such as culverts and ledges, were visited frequently by bobcats.

D. Ripley and H. Hart, experienced cat hunters, ran a 15-pound male bobcat at Blanford, Massachusetts, for two hours before treeing it. During the entire chase this cat carried a cottontail which it buried in the snow before climbing a tree. A bobcat, in February, 1949, was tracked in the township of Leverett, Massachusetts. It is estimated that this cat traveled approximately six miles from the site of last lying up to the time last tracked. According to D. T. Ford who accompanied the observer, this cat was believed to be a male as it backed up to a rock to urinate. Ford stated that a female cat will squat to urinate and then usually cover the urine while the male always backs up to an object.

It is probable that man is responsible for the greatest mortality of the bobcat. However, disease may well be an important decimator although there are no records of bobcat epizootics. Of the total number of cats shot or trapped in the months of November and December (72), it is estimated that over 75 per cent were killed by deer hunters. A 5¼-pound female was killed by a car. Disease, possibly rabies, might be a limiting factor. A 6½-pound male cat, received from New Hampshire, was found dead behind a farmer's barn. A close examination of this cat revealed no apparent cause for its death, yet it was in an emaciated condition. This cat was not examined for rabies. A large male New Hampshire cat was killed in the woods after being found in a paralyzed condition. This cat presumably could

not urinate, since its bladder contained over 800 cc. of urine. The cause of this paralysis was attributed to gunshot wounds. A 6-pound female cat killed on May 30, 1949, in Massachusetts by a conservation officer, had a severe infection of the mange mite, *Neotedres* sp. This animal was emaciated and should have weighed about 12 pounds. The conservation officer stated that this cat slowly moved across the road in front of him, and when pursued lay under a hemlock tree and snarled until disposed of.

A female cat which I trapped died after being kept captive for 47 days. It should be noted that it is practically impossible to keep small cats alive for long in this area, unless they are immunized for the so-called "cat enteritis."

Control by the use of the bounty system has long proved ineffective. An exception appears to be in Pennsylvania where Gerstell (Penna. Game News, 7: 8–10, 15, 24, 1937) stated, "Because the bounty system has not only brought the bobcat under complete control, but even placed the species . . . on the verge of extinction, the payment of the bounties for the killing of wildcats should be discontinued and serious consideration should be given the thought of offering the species some form of protection." The wisdom of controlling the bobcat in this state appears questionable in view of the excessive deer population. The bobcat being a sly and secretive creature makes control by den hunting or poisoning difficult. Those cats that are destructive to poultry can easily be trapped at the scene of destruction. Control is effected largely by bobcat hunters whose numbers are increasing yearly.

All freshly-killed bobcats were examined for ectoparasites. It was found that most fleas will stay on their host a considerable time after the cat's death. Over a dozen fleas (*Cediopsylla simplex* Baker) were collected from a bobcat that had been dead for more than five days. This specimen was kept isolated in a woodshed, thus eliminating the possibility of having acquired these fleas by transmission from another host. *Hoplopryllus glocialis lynx* Baker was also recovered from bobcats.

The gastro-intestinal tracts of 100 bobcats were examined for parasites. Only two tracts showed no signs of parasites. In the remaining tracts the number of helminth parasites ranged from a few to over a hundred. The cestode, *Taenia lyncis* Skinker, was most frequent, comprising half of the parasites identified. Other helminth parasites found were *Taenia laticollis*, *Toxocara cati*, *Physaloptera* sp., *Porocaecum* sp., and *Anisakis* sp. The mange mite, *Neotedres* sp., was identified and has been referred to above.

Thanks are expressed to the Massachusetts Cooperative Wildlife Research Unit and its cooperating agencies (U. S. Fish and Wildlife Service, Massachusetts Division of Fisheries and Game, University of Massachusetts, and the Wildlife Management Institute) for financial support, and to Dr. W. J. Hamilton, Jr., Department of Conservation, Cornell University, Ithaca, New York, and Dr. William G. Sheldon, Leader, Massachusetts Cooperative Wildlife Research Unit, University of Massachusetts, Amherst, Massachusetts, for their assistance and advice in this study. A. McIntosh, Beltsville, Maryland, identified the helminth parasites.—E. Michael Pollack, *Millerton, N. Y., Received September 8, 1950.*

CARNIVOROUS GROUND SQUIRRELS ON ST. LAWRENCE ISLAND, ALASKA

Otto William Geist (Jour. Mamm., 14: 306–308, 1933) gives the first account of the meat-eating tendencies of the ground squirrel, *Citellus lyratus* Hall and Gilmore, on St. Lawrence Island. During his excavations at the old village site of Kukuliak, located a few miles east of the present village of Savoonga, he observed some adult ground squirrels "eating the old partly dried and partly frozen lumps of whale and walrus meat which we excavated at an approximate depth of eight feet under the surface." He also reports having seen a ground squirrel eat a freshly killed mouse which had been shot by the teacher's son from Savoonga.

This past summer I was engaged in field investigations on St. Lawrence Island under a grant from the Arctic Institute of North America with funds provided through contractual arrangements with the Office of Naval Research; and during the month of July, while at Boxer Bay, I was able to make some additional observations on the food habits of ground squirrels.

On July 19 I discovered that two No. 1 steel traps, which had previously been set by my companion, Mr. George Schuman, at the entrances to a ground squirrel mound, had been dragged underground. Upon recovering these two traps I found in each the partly eaten remains of a half-grown ground squirrel. Suspecting that these animals might have been devoured by their parents or siblings, I left their remains in the traps by the burrows and retreated to a reasonable distance to watch. In less than fifteen minutes a young ground squirrel emerged from one of the holes and immediately began to feed on one of the dead animals. Presently two others, the same size as the first, also appeared and began feeding on the other carcass. The following day I returned to the mound and found nothing but the skins, feet, and heads remaining attached to the traps. The skins had been completely inverted as though the animals had been case-skinned, and all flesh and fat eaten away from the fleshy side. On subsequent days I left the carcasses of birds by this mound, including such species as the murres, puffins, gulls, and the snow bunting, and in each case these were readily eaten by the young squirrels. No adult squirrels were seen at this mound and it was assumed that the parent animal had been trapped earlier at some other hole.

Two other immature squirrels which had their burrow under a shack by our living quarters at Boxer Bay were fed both fresh and smoked salmon-trout, which they evidently relished, for they would eat up a strip weighing about a pound in two or three days.

During July at least, the vegetable foods of these squirrels seemed to consists entirely of young succulent grasses and forbes, particularly the former. In every case observed these animals ate at the source of their food supply, and there was no evidence that they stored food of any kind.

These observations, coupled with those of Mr. Geist, indicate that these ground squirrels eat meat in considerable amounts whenever it is available to them, and it is not, I think, stretching the point too far to suppose that meat in one form or another normally composes a significant portion of the food of Arctic ground squirrels in general. They are notable beggars about the mining camps in the Kougarok country of Seward Peninsula, and I have had more than one cook tell me about their preference for meat scraps. An army cook at Quartz Creek even told me that he had seen them eating each other, and this information was offered without prompting on my part. These indications of carnivorous tendencies in the Arctic ground squirrels certainly warrant further study.

That these rodents are canabalistic in any strict sense of the word is unlikely, except perhaps under undue populational stress as at a peak period in their numbers, but my data do seem to indicate that they will feed on dead, sick, or handicapped individuals of their own kind whenever the opportunity is afforded. It seems equally unlikely that they actually pursue and kill many animals for food, though I suspect that they occasionally steal the eggs and young of cliff-nesting birds; however, I have no actual evidence of this having happened in any of the bird colonies studied on the island.

Charles G. Wilber and X. J. Musacchia (Jour. Mamm., 31: 304–309, 1950) have recently discussed certain aspects of fat metabolism in the Arctic ground squirrel, *Citellus barrowensis* Merriam, pointing out that this animal "thrives in its northern habitat and hence it must have solved the problem of balancing the budget of heat loss versus heat production." I am not prepared to make a detailed analysis of their findings, but they seem to conclude that "balancing the budget of heat loss versus heat production" involves for the Arctic ground squirrel the possession of a relatively high level of fat metabolism. Their study shows that the level of fat metabolism in the ground squirrel is higher than for either the dog or the rabbit. It is further stated that this mechanism may be adaptive in nature, making for the survival of the ground squirrel in "a very vigorous climate." It would be interesting to know whether there is any significant difference in the production and storage of fats between Arctic and temperate or sub-tropical species of *Citellus*. Assuming that there may be a measurable difference, it would again be interesting to know how much this may be due to a more efficient mechanism for fat metabolism and how much it may be due to difference in diet between the northern and southern groups. My data indicate a rather constant predilection among Arctic ground squirrels for foods of high fat content. If more animal fats are eaten by Arctic ground squirrels than is commonly supposed, this fact

would seem to me to be equally as important in explaining the relatively high level of fat production and storage in Arctic ground squirrels as any adaptive physiological mechanism for the more efficient synthesis of fats.—Tom Cade, *College, Alaska. Received December 7, 1950.*

MEASUREMENTS AND WEIGHTS OF NORTHERN MUSKRATS

The northwestern muskrat, *Ondatra zibethica spatulata* (Osgood), apparently occupies an extensive range in northwestern North America. Hollister (N. Amer. Fauna 32, 1911) in his revision of the genus *Fiber* (= *Ondatra*) attempted to map the ranges of the various races, but realized that existing collections were not always adequate for accurate delimitation. This applies with special force to the northern races *spatulata* and *alba*. The situation is still relatively unchanged. The purpose of the present paper, therefore, is to place on record a series of measurements and weights of muskrats, known to have reached sexual maturity, from an area near the southeastern extremity of what is generally considered to be the range of *spatulata*.

The data to be reported on were collected in the course of a survey of the ecology and economic importance of the muskrat in the Athabasca–Peace delta in northeastern Alberta, and the Slave River delta in southern Mackenzie District, Northwest Territories, Canada.

Early work on the northwestern muskrat was done by biologists of the Bureau of Biological Survey who were primarily interested in formulating a complete fauna of the regions visited. Extensive collections of skins were made but, understandably, the series representing a given species or race was small, and the number of adults smaller still. Furthermore, these early northern explorers were compelled to work along the major waterways, which were the only practical routes of travel.

Ondatra zibethicus spatulatus was first described by Osgood (N. Amer. Fauna 19, 1900) as a distinct species, (*Fiber spatulatus*). His measurements of the type specimen (a young adult female) were taken from a dry skin. Osgood stated (p. 37) that *spatulata* was much different from *osoyoosensis*, and postulated "that *Fiber spatulatus* is the form occupying all of northwestern America, and is derived from a form east of the Rocky Mountains rather than from a western one."

Hollister (*loc. cit.*) remarked that, to a certain degree *Fiber zibethicus albus* "combines the characters of true *zibethicus* with those of *spatulatus* . . . To the northwest the intergradation with *spatulatus* is very clear, and specimens from the Athabaska and the Mackenzie regions, though unquestionably referable to *spatulatus*, are certainly intermediate." (p. 21). He further stated (p. 24) that *Fiber zibethicus osoyoosensis* resembles *spatulatus*, but is larger and darker. Average measurements of specimens were given.

Preble (N. Amer. Fauna 27, 1908) stated (p. 192) that he was led to refer his Mackenzie series to *spatulatus* "though a number, especially those from Athabaska and Great Slave lakes, are somewhat intermediate and might without impropriety be referred to *hudsonius* [= *alba*]." His series was composed of specimens referable to the region now under discussion. Soper (Jour. Mamm., 23: 119–145, 1942) referred his specimens from Wood Buffalo National Park to *spatulata*.

It is apparent from the foregoing that the specimens to be reported on derive from an area of possible intergradation between *Ondatra zibethica spatulata* and *Ondatra zibethica alba*. In view of the paucity of previous information concerning the status of the northern muskrats, it is hoped that this analysis of the measurements of a series of 96 sexually mature muskrats will be of interest and value.

Eighty-one specimens were obtained through the good offices of Mr. Solomon Lacaille, a trapper, living in Wood Buffalo National Park, at approximately latitude 58° 20′ N and longitude 111° 30′ W. Mr. Lacaille was provided with special permission to take muskrats at bi-weekly intervals for examination by the writer. He also very kindly made available for examination several hundred muskrats taken by him as part of his trapping operations in the regular open season (at that time March 1 to May 15).

Measurements were taken with a steel rule calibrated in sixteenths of an inch, or (the

majority) on a measuring board marked off in millimeters. Some of the specimens were measured before skinning, while others were skinned and the carcasses frozen pending the monthly visits of the writer. It is believed that no significant error was introduced by measuring skinned carcasses. Since the pelts for market were prepared as cased skins, the feet and tail were not skinned out, and, therefore, were not stretched or mutilated.

All weights were taken on the same spring balance calibrated in 25-gram intervals. Wherever possible the specimens were weighed both before and after skinning in order to arrive at a factor for converting carcass weight to round weight for another study. All weights reported in this paper, however, were secured before the animals were skinned.

Specimens were aged according to the condition of the reproductive tracts on autopsy. Those which showed evidence of sexual maturity were considered to be adults regardless of chronological age. In March, for example, most of the animals were undoubtedly young of the previous summer. Since it was impossible, at this season, to distinguish between young of the previous year and older animals by any method, it seemed mandatory to consider all sexually mature animals full grown. At all other seasons for which specimens were available, it was possible to separate older animals from young of the year.

TABLE 1.—*Measurements (mm.) and weights of muskrats from northern Alberta*

		TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT	WEIGHT, GRAMS
Male	Average	572.0	256.1	75.7	1131.6
	Standard Deviation	24.9	14.2	2.3	202.8
	Range	496–616	222–282	70.0–81.0	750–1575
Female	Average	561.8	250.0	74.5	1053.4
	Standard Deviation	19.9	15.0	2.8	128.0
	Range	513–596	195–278	68.0–80.0	800–1375
Both Sexes	Average	567.7	253.0	75.2	1112.2
	Standard Deviation	20.4	14.9	2.5	170.5

The distribution of these specimens by months was as follows: January, 10; February, 2; March, 41; May, 1; July, 4; August, 1; September, 1; October, 5; November, 6; December, 10; total, 81.

An additional 15 adult specimens were taken in the delta of the Slave River in the summer of 1949 and May and June, 1950, by officers of the Canadian Wildlife Service. Acknowledgment is hereby made to Mr. C. E. Law and Mr. C. R. Slater for supplying the following data on these specimens: total length, ave., 531 mm. (450–600); tail vertebrae, 246 (204–275); hind foot, 73.5 (65–78); wt., 932 grams (680–1230). All average measurements shown in Table 1, which includes only the Alberta material, are based on 41 males and 40 females, except that for the hind foot of the females which is based on only 39 specimens. The average weights are based on 33 males and 34 females. There are constant differences between the sexes which, however, are not statistically significant at the 5 per cent level.

Attention is directed to the wide fluctuation in weight. The animals appear to be lightest in summer and the weight increases through the winter by deposition of subcutaneous fat. It reaches a maximum just prior to the onset of breeding, probably in late March or early April. Thus the full range of variation is not usually encountered at any one season.

Osgood (*loc. cit.*) called the northwestern muskrat a small race, but as Table 2 shows, it compares favourably in size with typical *zibethica* and other adjoining races. It is possible that Osgood was misled by his own measurements of the type specimen, which were taken from a dry skin. Measurements alone, of course, do not prove affinities, but in size at least,

spatulata appears to be as close to typical *zibethica* as to any of the three races whose ranges it may possibly overlap.

Size is extremely important in relation to the economic value of the pelt, particularly so in a form such as the muskrat where colour is relatively unimportant. The northwestern muskrat produces pelts with heavy leather and dense underwool, which compare favourably in size with those of most of the other races.

TABLE 2.—*Average measurements (mm.) of some races of Ondatra zibethica as recorded in the literature*

RACE	AUTHORITY	NO. OF SPECIMENS	TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT
spatulata	Osgood (1900)	1[1]	495	170	73
	Hollister (1911)	4	530	232	74.5
	Preble (1908)	5	546	264.4	75
	This paper	96	551	252	74.9
alba	Hollister (1911)	8	541	239	75
	Preble (1902)[2]	6	546	240	74.9
zibethica	Hollister (1911)	7	563	254	81
cinnamomina	Hollister (1911)	2	496	240	73.5[3]
osoyoosensis	Hollister (1911)	10	589	271	83

[1] Taken from dry skin of type specimen.
[2] N. Amer. Fauna 22, 1902.
[3] Hind foot measurement based on 21 specimens.

Summary.—The present paper places on record the average standard measurements of 96 sexually mature specimens of the northwestern muskrat, and the weights of 82. This is a larger series than has heretofore been available for this race and the analysis indicates that it compares favourably in size with typical *zibethica*, although it has been characterized as a small race.—W. A. FULLER, *Canadian Wildlife Service, Fort Smith, N. W. T. Received January 17, 1951.*

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ZAPUS WITH WHITE TAIL-TIP

Six specimens of *Zapus hudsonius hudsonius* were trapped between September 23 and October 7, 1950, on an area of about five acres at the western end of Six Mile Creek marsh, town of Springfield, Dane County, Wisconsin. Three of the specimens had white tail-tips measuring as follows: male, 6 mm.; male, 4 mm.; female, 12 mm. A similar type of albinism in this species does not appear to have been recorded previously.—A. W. SCHORGER, *168 N. Prospect Ave., Madison, Wis. Received December 26, 1950.*

BREEDING RECORD OF THE COATI MUNDI IN THE UNITED STATES

On July 30, 1947, while engaged in collecting activities in southern Arizona, a newly-born individual of the coati mundi, *Nasua narica pallida*, was picked up at an altitude of 5600 feet, in Madera Canyon, Santa Rita Mountains, Santa Cruz County, by Mr. G. Morejohn, Jr. The animal had been dead for some time, and portions of the skull had been eaten by mice. Since the specimen was recognizable as a coati, it was preserved in alcohol. It now bears the Los Angeles County Museum number 8823.

Records of this animal ranging from Sonora and Chihuahua into Arizona and New Mexico are now quite common. It has heretofore been postulated, however, that at least a significant portion of the coatis present within the national boundaries have migrated there as indi-

viduals from their more typical range to the southward. The fact that young are born within the confines of the United States, in the areas whose faunal affinities are probably with the Sierra Madre Occidental of Mexico, definitely indicates this species to be a permanent breeding resident within the United States.—WILLIAM G. REEDER, *Los Angeles County Museum, Los Angeles, California. Received January 26, 1951.*

WISCONSIN'S FIRST PRAIRIE SPOTTED SKUNK, AND OTHER NOTES

On November 19, 1946, a fox trapper, L. L. Bailey of Hudson, Wisconsin, captured a prairie spotted skunk (*Spilogale interrupta*) in Section 25, T. 30 N., R. 19 W., St. Croix County. He saw tracks of another nearby at the same time. According to H. H. T. Jackson of the U. S. Fish and Wildlife Service, in a letter to me dated December 26, 1946, this is the first record of the species for Wisconsin so far as is known. He also indicates he has searched every mile of the Wisconsin side of the Mississippi river for a sign of this species without success and the record is "especially interesting as coming from so far north in the state." He presumes that the wide Mississippi farther down has proven too much of a barrier. Through the help of Conservation Warden Lawrence Hope of Hudson, the skin of this specimen was secured. It is preserved at the University of Wisconsin Museum of Zoology as number UWZ-12965.

On November 4, 1950, a raccoon hunter, Albert K. Larson of Route 2, Nelson, Wisconsin, shot a male raccoon (*Procyon lotor hirtus*) in T. 24 N., R. 12 W., Buffalo County, Wisconsin, which was weighed in on an accurate platform scale before witnesses at 62 pounds, 6 ounces. Another less accurate hanging spring scales recorded 59 pounds, 6 ounces. When this data was double-checked with the trapper he also reported the following gross measurements on this specimen: 4 feet 7 inches, length from tip of nose to tip of tail; 17¼ inches wide across back on specimen in the flesh. The trapper stated the specimen was very fat and judged to be about three years old. The heaviest weight listed for this subspecies is 30½ pounds according to Edward A. Goldman's recent N. A. Fauna 60 on the raccoons.

In Wisconsin's 1949 season on beaver (*Castor canadensis missourensis* (?)), (February 10 to 28), several counties were opened for the first time in many years and some exceptionally large specimens were reported. Reported data on three specimens were checked with the trappers and weights are given here as they were taken on good scales before witnesses. On the 25th, Ben C. Gluesing of Whitehall took a 72-pound specimen in the Town of Shelby, La Crosse County. It measured 46 inches from tip of nose to tip of tail and blanket measured 78 inches across. On the 26th, Fred O'Dell of Victory took a 72-pound specimen in the Town of Genoa, Vernon County. It measured 56 inches from tip of nose to tip of tail and the blanket was 84 inches across. On the 13th, Orlan Reed of Lynxville captured a female specimen weighing 69 pounds 6 ounces near that town in Crawford County.

In 1949 the Wisconsin Conservation Department acquired for their museum in the State Game Farm at Poynette a female specimen of the lynx (*Lynx canadensis canadensis*) which had been killed by Mike A. Schmitz of Stanley on October 8, 1908, in Section 27, T. 28 N., R. 6 W., in Chippewa County. There are few authentic lynx specimens, skins or mounts, from Wisconsin.—WALTER E. SCOTT, *Wisconsin Conservation Department, Madison, Wisconsin. Received December 26, 1950.*

UNUSUAL RECORD OF THE OCELOT IN TEXAS

In early December, 1950, Arthur Wingate killed an ocelot (*Felis pardalis*) on the H. Hogard farm 2½ miles northeast of Hedley, Donley County, Texas. The animal was flushed from a patch of weeds near a cotton field. It weighed about 45 pounds and had a total length of 4 feet 6 inches.

Hedley is approximately 65 miles southeast of Amarillo, in the panhandle section of Texas, and fully 350 miles north of Kerr County, the previous northernmost record in the state. According to R. J. Gilbreth, a resident of Hedley, a bus driver saw another ocelot in the vicinity of Clarendon about mid-December.

A photograph of Wingate and the ocelot he killed appeared in the December 8, 1950, issue of THE HEDLEY INFORMER.—W. B. DAVIS, *Department of Wildlife Management, College Station, Texas. Received January 17, 1951.*

MOUNTAIN LION IN ARKANSAS

Young and Goldman in their book, THE PUMA MYSTERIOUS AMERICAN CAT, list a number of reports of the mountain lion, *Felis concolor*, occurring in Arkansas from 1919 to the last reported occurrence in Franklin County on September 25, 1920. Seton in his LIVES OF GAME ANIMALS also mentions hunters reports of this mammal occurring in the northwestern corner of the state as late as 1920. In view of its supposed extinction in the state it seems appropriate to bring to attention some recent reports of its occurrence.

The ARKANSAS GAZETTE of December 3, 1949, ran an account of a mountain lion shot about 8 miles west of Mount Ida, Montgomery County, around the latter part of November or early December by Virgil McKinney and Tom Dillard of Sims, Arkansas. A photograph of the animal was taken of which a copy was secured from the Whitting Pharmacy, Mount Ida, Arkansas. Study of the photograph reveals the record to be an authentic one.

The writer, in correspondence with Mr. Tom Dillard, has established that the specimen measured 7 feet in length and weighed 134 pounds. It was actually killed about two miles north of Sims, Montgomery County, Arkansas. Mr. Dillard did not ascertain the sex, but from the photograph it appears to be a female. He has the head mounted although the writer has not had opportunity to examine it.

The ARKANSAS GAZETTE account reports that this mountain lion was the second reported within a week. Another was supposedly trapped by a farmer near Warren, Bradley County, who said that tracks indicated three more were at large in the vicinity.—JOHN A. SEALANDER, *Dept. of Zoology, University of Arkansas, Fayetteville, Arkansas. Received December 9, 1950.*

ALASKA FUR SEALS, *CALLORHINUS URSINUS*, OBSERVED OFF SAN FRANCISCO BAY, CALIFORNIA

During the early spring of 1950 the writer and others of the staff of the California Academy of Sciences were engaged in studies of the geology off the coast of central California under the auspices of the Office of Naval Research.

This work was done under Contract No. N9 onr 94400-01, and the net tender U. S. S. *Mulberry* was assigned to the work. The primary purpose was the determination of the nature of the bottom rocks on the continental slope from 100 fathoms down, including the formation exposed on the outlying seamounts. During the several trips made to sea opportunity was afforded to make observations and collections in other branches of science than geology. This note is prompted by the excellent article by Victor B. Scheffer, "The Food of the Alaska Fur Seal" (Trans. 15th N. Amer. Wildlife Conference: 410–421, 1950) and also by the later report by Oliver J. Austin, Jr. and Ford Wilke entitled "Japanese Fur Sealing" (U. S. Fish and Wildlife Service, Special Scientific Report—Wildlife, No. 6: 1–91, 15 text figs., bibl. 301 titles, 1950) This last report is a republication of Rept. No. 129 issued by the Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, Tokyo, July, 1950.

Each trip from San Francisco comprised a week, and much of the time was spent where the water was more than 100 fathoms in depth. At times the ship anchored overnight in as much as 750 fathoms.

Beginning in February, fur seals were seen almost every day. Our routine duties prevented us from making a special effort to record the numbers or study their habits, but the observations made, casual though they be, may be of sufficient interest for preservation. The notes are reproduced below by station number as they were jotted down at sea. Few deductions can be made. However, it may be worthwhile to call especial attention to the fact that no adult males were seen. Most of the animals observed at close range were adult females, recognized by the light color of the "whiskers." A few were no larger than two-

year olds and may have been of either sex. One no larger than a yearling was seen. Station 48 at the head of Pioneer Sea Valley in 100 fathoms was most interesting. There probably was an up-welling of water there, rich in food, because in addition to the 50 fur seals noted there were many porpoises and countless sea birds. Pteropods were especially abundant in the early evening and it may well be that these mollusks were the chief attraction at the time.

One other observation seems especially important. We were anchored on the seamount just northwest of Pioneer seamount, 46 miles off Point Montara, in 750 fathoms on the night of April 6-7. The slope to the westward steepens rapidly to a depth of 1500 fathoms. The well-known ichthyologist, Mr. W. I. Follett, spent the night with dip net catching lanternfishes alongside the ship, a cargo light giving him illumination. These fishes spend the daylight hours in the depths and come to the surface to feed at night. They have rows of luminous organs which make them conspicuous at times on a dark night. While engaged in this work Mr. Follett was disturbed for a time by two fur seals which were obviously concerned with the same occupation. It was sometimes a question which collector would be successful in catching a particular fish. Mr. Follett has furnished the following identifications of the fishes collected on this occasion: *Tarletonbeania crenularis* (blue lanternfish), 81 specimens half grown to adult; *Myctophum californiensis* (California lanternfish), one adult specimen; *Anoplopoma fimbria* (sable fish), one young specimen; *Hemilepidotus hemilepidotus* (spotted frishlord), two young specimens.

Field Notes.—Station 31, February 8, 1950. Fifteen fur seals were seen in the vicinity of Pioneer Seamount, Lat. 37° 18.7′ N.; Long. 123° 28.2′ W. No more than 4 were seen in a single group.

Station 37, February 9, 1950. Approximately 8 miles south of Southeast Farallon Island. It was estimated that 75 fur seals were seen during the day. They were about as common in water 30 to 50 fathoms in depth as where it was 1000 fathoms or more. No males could be identified among those seen at close range.

Station 47, February 16, 1950. Approximately nine miles southwest of Pioneer Seamount. Lat. 37° 04′ 30″ N.; Long. 123° 04′ 30″ W. Fifteen fur seals were seen while making a dredge haul in 600 fathoms.

Station 48, February 16, 1950. Head of Pioneer Sea Valley. About 50 fur seals were apparently feeding upon some forms of small organisms. With them there were many porpoises and great numbers of sea birds. Pteropods (Mollusca) were especially common among the plankton forms caught in a few hauls with dip net.

Station 55, March 28, 1950. On way from Drakes Bay to Cordell Bank, 20 fur seals were cited. In one group, 12 were counted. The depth of the water was 50–55 fathoms.

Station 64, April 5–6, 1950. At anchor on seamount (tentatively called Mulberry) just northwest of Pioneer seamount, 46 miles west of Point Montara, 750 fathoms. This is about 14.75 miles southwest of Southeast Farallon Island. Twelve fur seals were seen in the vicinity during daylight hours, and two at night, feeding on lanternfishes.—G. D. Hanna, *California Academy of Sciences, San Francisco, California. Received December 30, 1950.*

PROBABLE RECORD OF THE BEAKED WHALE, *ZIPHIUS CAVIROSTRIS*, IN BAJA CALIFORNIA

In this journal (Vol. 27: 241–44, 1946) I reported a specimen of *Ziphius cavirostris* Cuvier that was stranded at Del Mar, Southern California, as the first record for the Pacific Coast south of British Columbia. Since then Orr (Jour. Mamm., 29: 420–21, 1948) has listed another, from northern California. Since the species (or species group) is cosmopolitan, further records, still farther south, have been anticipated. The highly probable occurrence of this beaked whale in Baja California may now be reported.

Early in December, 1950, a cetacean that appears almost certainly to have been of this species was found by Mr. H. L. Goddard, of Carlsbad, California, stranded on the beach of San Ramón, at the south end of the lagoon at the mouth of Río Santo Domingo, at 30° 42.7′ N. Lat. According to Mr. Goddard it was 18 feet long and had typical whale flukes.

He says that the lower jaw projected about 4 inches and caried at its extreme tip a pair of strong erect teeth implanted in the flesh less than an inch apart. The tooth that he removed is 59.0 mm. long, 21.5 mm. in lesser diameter, and 30.5 mm. in greater diameter. The maximum width is well above the base, but considerably below the middle of the height of the tooth. The correspondence is very close with a tooth of this species figured by True (U. S. Nat. Mus., Bull. 73: pl. 38, figs. 10–11, 1910). The number, size, position, and erect orientation of the teeth appear to be diagnostic of *Ziphius*. The only possible confusion would seem to be with *Hyperoodon*, which has not yet been reported reliably from the northeastern Pacific.

The tooth is deposited in the mammal collection of the San Diego Society of Natural History (No. 2631).—Carl L. Hubbs, *Scripps Institution of Oceanography (University of California), La Jolla, California.* *Received January 8, 1951.*

[Contributions from the Scripps Institution of Oceanography, New Series, No. 523.]

ADDITIONS TO THE FAUNA OF SANTA CRUZ ISLAND, CALIFORNIA, WITH DESCRIPTION OF A NEW SUBSPECIES OF *REITHRODONTOMYS MEGALOTIS*

Santa Cruz Island, one of the Channel Islands of southern California, lies 20 miles off the coast of Santa Barbara County. It is composed of 62,000 acres of grassland, eroded hilltops almost bare of vegetation, chaparral, scrub, pine forest, and patches of oaks and other hardwoods. Habitats are in general the same as those found on the adjacent mainland of California, but the number of mammalian species living on the island, as on all the Channel Islands, is small. Deer mice, gray foxes, spotted skunks, and little California bats have been the only native land mammals reported heretofore from the island. Through the kindness of Mr. Edwin L. Stanton, owner of a large part of the island, Dr. Frank A. Pitelka and I were able to collect from August 28 to September 14, 1948, and, with the aid of Mr. J. W. Sefton and the Research Ship "Orca," Dr. Alden H. Miller and Mr. John R. Hendrickson collected from March 5 to 12, 1950. As a result we are able to add three genera, *Antrozous*, *Corynorhinus*, and *Reithrodontomys*, to the four already known from the island. The following mammals are now known to live on the island.

Myotis californicus caurinus Miller. Little California bat.—Miller and Allen (U. S. Nat. Mus., Bull. 144, 1928) assigned three specimens from Santa Cruz Island to *M. c. californicus*, but stated that these were "not typical." Twelve additional specimens taken at Prisoner's Harbor in September, 1948, resemble the dark, richly colored coastal form to the north more than they do *californicus*, and I list them accordingly.

Corynorhinus rafinesquei intermedius H. W. Grinnell. Lump-nosed bat.—A nursery colony of about 200 adult females and grown young occupied an attic at Prisoner's Harbor in September, 1948. Two adult males were taken in buildings at the Christy Ranch near the west end of the island. A series of 23 is indistinguishable from *C. r. intermedius*.

Antrozous pallidus pacificus Merriam. Pallid bat.—A colony of several hundred occupied the winery at the ranch headquarters in the central interior of the island. A series of 16 matches closely a series of this race from the mainland.

Spilogale gracilis amphialus Dickey. Spotted skunk.—Six were trapped. Stomachs contained insects, *Peromyscus*, fruits of *Comarostaphylis*, and grapes obtained in an abandoned vineyard.

Urocyon littoralis santacruzae Merriam. Island fox.—This fox apparently has pronounced cycles of abundance. One person living on the island stated that he has seen as many as 100 in a day. We saw none during our visit in 1948, but trapped four. Stomachs and scats showed that they had been feeding primarily on fruits of *Comarostaphylis* and *Arctostaphylos*, but also to some extent on large arthropods (some of them probably marine crustaceans), mice, birds, and carrion of sheep.

Reithrodontomys megalotis santacruzae, new subspecies. Harvest mouse.

Type.—Adult male, skin and skull, Museum of Vertebrate Zoology No. 113604, from

Prisoner's Harbor, Santa Barbara County, California, March 7, 1950. Collected by A. H. Miller (No. 7579), measured and prepared by O. P. Pearson (No. 1938).

Distribution.—Known only from Prisoner's Harbor on the north shore of Santa Cruz Island.

Diagnosis.—A large, long-tailed, relatively gray subspecies of the *megalotis* group.

Comparisons.—Compared with *R. m. longicaudus*, which is widely distributed along the coast of California, the Santa Cruz Island form has a longer body, longer tail, and longer, more lax pelage; it is grayer and less richly colored. The skulls of *santacruzae* average larger in greatest length, zygomatic breadth, and width of braincase. *R. m. santacruzae* differs in the same characters from specimens of the Monterey Bay harvest mouse, *R. m. distichlis* von Bloeker, a form that I cannot distinguish from *longicaudus*. The Santa Cruz Island form is likewise longer-tailed and grayer than a specimen of *R. m. limicola* von Bloeker, and each Santa Cruz Island specimen has a tail longer than the average of the eight adults of *limicola* from the marshes of Orange, Los Angeles, and Ventura counties reported in the description of *limicola*. *R. m. limicola* is described as being less gray than *longicaudus* whereas *santacruzae* is more gray. The Santa Cruz Island specimens are grayer, less richly colored, and have smaller bodies, tails, feet, and skulls than specimens of *R. catalinae* from Santa Catalina Island, a form that I am inclined to consider as a subspecies of *R. megalotis*.

Color.—Upper parts predominantly Ochraceous Buff (capitalized colors are from Ridgway, 1886, A Nomenclature of Colors) lined with black, but becoming noticeably grayer on back of neck and shoulders. Sides and cheeks brighter buff than back, ears clothed within with buff hairs. Underparts grayish white with conspicuous pectoral streak of Buff. Tail bicolor, Hair Brown above and light Smoke below. Feet white above. Coloration in general is similar to that of *R. m. longicaudus*, but less bright.

Measurements.—Type: total length, 156 mm.; tail, 88; hind foot, 18; ear from notch, 15. Average and extremes of four topotypes: total length, 158 (152–161); tail, 87 (85–89); foot, 18 (18–18.5); ear 13.5 (13–14). Skull of type: greatest length, 21.3; zygomatic breadth, 10.7; interorbital breadth, 3.0; width of braincase, 10.3; length of maxillary toothrow, 3.0. Average and extremes of four topotypes: greatest length, 21.2 (20.8–21.8); zygomatic breadth, 10.8 (10.7–11.0); interorbital breadth, 2.9 (2.8–3.0); braincase, 10.2 (10.1–10.2); toothrow, 3.1 (3.0–3.3).

Specimens examined.—Five adults and one immature, all from the type locality.

Remarks.—Two of the specimens were taken in September, 1948, and four in March, 1950. All were captured near the junction of a small grassy field with a small fresh-water marsh that was filled with tall *Scirpus*, *Typha*, and willows. The amount of such habitat available at Prisoner's Harbor probably would not support more than a dozen or so pairs of *Reithrodontomys*, and the area is separated from any other possible patch of similar vegetation (and there may not be any) by long stretches of dissimilar habitat in which extensive trapping revealed no *Reithrodontomys*. Consequently, it is probable that the total population of this subspecies is extremely small.

Peromyscus maniculatus santacruzae Nelson and Goldman. Deer mouse.—These were caught in considerable numbers in every kind of habitat. Despite the fact that over most of the island they have no competition from other rodents, their population density did not seem to be markedly higher than on the mainland. There were only three mammalian predators, foxes, skunks, and a few feral cats, and these were not present in unusual numbers. Barn, burrowing, and horned owls have been reported from the island, as well as gopher snakes, blue racers, and several species of hawks.

Several domesticated species are important in the ecology of the island:

Cattle.—Fattening of cattle is the most important industry on the island at the present time, but because of drought no cattle were present during our visit in 1948.

Sheep.—Large numbers were at one time tended on the island, but have gone wild and have become so well established that, according to ranchers, more than 10,000 have been shot in the last few years in an attempt to exterminate them. We were told that about 2000 still survived in 1948.

Swine.—Feral pigs are common. A drastic reduction in numbers was caused by the intentional introduction of hog cholera, but some have survived. Numerous scats were seen containing acorns, and the stomach of a nursing sow killed by ranch hands on September 2 contained fruits of *Opuntia* and manzanita.

Cats.—Although we saw none, we were told that feral cats were present.—OLIVER P. PEARSON, *Museum of Vertebrate Zoology, University of California, Berkeley, California.* *Received December 27, 1950.*

NOTES ON MAMMALS FROM WEST VIRGINIA

Numerous writers, among them A. B. Brooks (1929), F. E. Brooks (1911), Kellogg (1937), Wilson (1946), and Wilson and Friedel (1941), have published on the mammals of West Virginia. However, the distribution and natural history of many species occurring in the state is but sketchily known.

From February, 1949, until July, 1950, while in the employ of Oglebay Institute, Wheeling, West Virginia, I collected mammals from the northern half of the state as other duties permitted. Especial thanks are due the governing bodies of Oglebay Institute for financial and moral support.

It is my purpose to herein record the results of collections made during this period. Specimens collected in Preston County in 1949 have been previously reported (Barbour, 1950) and are not duplicated here. All specimens are now in the zoological collections of the University of Kentucky. In the following annotated list, all measurements are given in millimeters except where otherwise noted. Averages are given first, followed by extremes in parentheses.

Didelphis v. virginiana Kerr. Virginia opossum.—The opossum has been observed DOR (dead on road) in Jackson, Ohio, Pleasants, Tyler, and Wetzel counties. Represented in the collection by 17 specimens (5 skins, 12 alcoholics) from Oglebay Park, Ohio County.

Four adult females were trapped, examined, tagged, and released in Oglebay Park on March 17, 25, and 27 and April 10, 1950. They were carrying 6, 12, 7, and 7 young in their respective pouches. Estimated birth dates of the young were February 9, 20, 12, and 17, respectively (derived from data published by Petrides, 1949).

Unfortunately, I was unable to recapture the four females discussed above to determine positively whether two litters were produced. Some circumstantial evidence supports the theory that the opossum, at least in the environs of Wheeling, does produce two litters. On August 14, 1949, a juvenile (total length, 544 mm.; tail, 223; hind foot, 41) taken in Oglebay Park had apparently been born early (February?) in the year. Two other juveniles, taken in the Park on August 2 and August 18, measured, respectively: total length, 238, 251; tail, 92, 104; hind foot, 27, 27. These latter specimens appear too small to have been born much earlier than June, indicating either two litters a year or a range of birth dates from early February until June. Due to the fact that all female opossums taken in the Park in March and April carried young, born probably in February, the former hypothesis is favored.

Parascalops breweri (Bachman). Brewer's mole.—This species is abundant in Oglebay Park, doing considerable damage to the golf course. I have examined two specimens collected in the Park in 1928 by Vernon Bailey. One specimen was taken near Terra Alta, Preston County, on June 12, 1950.

Condylura cristata (Linnaeus). Star-nosed mole.—One specimen was taken from a burrow in a marshy area bordering Lake Terra Alta, Preston County, on June 15, 1950.

Sorex f. fumeus Miller. Smoky shrew.—Two individuals were collected at Jackson's Mill, Lewis County; one from Oglebay Park, Ohio County; and two from Tomlinson's Run State Park, Hancock County. An adult female taken August 21, 1949, from Tomlinson's Run State Park, Hancock County, was lactating from six mammae.

Blarina brevicauda kirtlandi Bole and Moulthrop. Blarina.—All our specimens of *Blarina* are referred to *kirtlandi* pending further study of the genus. Measurements of 41 individuals from Oglebay Park, Ohio County, are: total length, 121.2 (110–133); tail, 25.3 (20–29; hind

foot, 15 (13–16). These figures compare favorably with the average of a series of ten individuals from Preston County (total length, 121.7; tail, 26.5; hind foot, 15.1) taken in 1949 (Barbour, 1950). Five specimens from Jackson's Mill, Lewis County, average: total length, 118 (111–123); tail, 25.4 (20–28); hind foot, 14.4 (14–15). In addition to the specimens mentioned above, I have three from Tomlinson's Run State Park, Hancock County, and one from three miles west of Bethany, Brooke County.

Lactating females were taken only in Oglebay Park. Three were taken on August 11, 24, and 27, 1949, respectively.

The short-tailed shrew appears to be one of if not the commonest small mammal in northern West Virginia. Individuals were taken from a wide variety of habitats, ranging from marshy areas through open grassland to dense woodland.

Eptesicus f. fuscus (Beauvois). Big brown bat.—A cluster of six individuals was discovered in the attic of the carriage barn in Oglebay Park, Ohio County, on September 1, 1949; two specimens were secured. On May 19, 1950, one individual was taken three miles west of Bethany, Brooke County.

Lasiurus b. borealis (Muller). Red bat.—Represented by a single adult male taken in Oglebay Park, Ohio County, on August 11, 1949.

Corynorhinus r. rafinesquei (Lesson). Big-eared bat.—My only specimens are an adult female and juvenile male taken by Wayne H. Davis on July 9, 1949, from a cluster in Tory's Cave, about ten miles south of Franklin, Pendleton County.

Procyon l. lotor (Linnaeus). Raccoon.—A juvenile male was collected in Oglebay Park, Ohio County, in January, 1950. Raccoons were sometimes observed in and about the Park. In July, 1950, a young raccoon was seen on the shore of Lake Terra Alta, Preston County. Numerous tracks were observed in Tomlinson's Run State Park, Hancock County, in August, 1949.

Mustela frenata noveboracensis (Emmons). Long-tailed weasel.—An adult was observed DOR in Oglebay Park in March, 1949. Two juvenile males (total length 287, 294; tail 85, 83; hind foot 39, 38) were taken from a litter of nine young observed May 26, 1950, along a road near Elm Grove, Ohio County.

Mephitis mephitis nigra (Peale and Beauvois). Striped skunk.—This species has been observed DOR in Brooke, Hancock, Lewis, Marshall, Monongalia, Ohio, and Preston counties.

Two pregnant females were captured in Oglebay Park in early 1949. One gave birth to a litter of five young on May 1, the other produced six young on May 5. The young at birth were blind and hairless, but pigmented areas in the skin revealed the future color pattern.

Skunks are abundant in Oglebay Park: considerable damage is done to the golf greens by their foraging.

Vulpes f. vulva (Desmarest). Red fox.—No red foxes were taken, but individuals have been observed in Oglebay Park and on upper Middle Wheeling Creek, Ohio County, and near Sherrard, Marshall County.

Urocyon c. cinereoargenteus (Schreber). Gray fox.—An adult female was found DOR in Oglebay Park, Ohio County, in January, 1950. A juvenile male was taken in Elm Grove, Ohio County, on August 18, 1949.

Gray foxes were frequently seen in Oglebay Park, and often exhibited little concern at the approach of man. I have approached within twenty paces of an adult in a closely mowed meadow without the animal exhibiting any particular concern; closer approach caused the animal to unhurriedly enter the open end of a long drainage tile.

Marmota m. monax (Linnaeus). Woodchuck.—My only specimen was taken in Oglebay Park, Ohio County, on March 17, 1949. The species has been observed in Hancock, Ohio, Preston, and Wetzel counties.

Tamias striatus fisheri Howell. Eastern chipmunk.—Five specimens were taken in Oglebay Park, Ohio County; two from Jackson's Mill, Lewis County; and three from near Terra Alta, Preston County. All are typical *fisheri*, readily separable from a comparable series of *lysteri* from New York and a series of *striatus* from eastern Kentucky. The species

has been observed in Oglebay Park in every month of the year; I have taken specimens in the Park from February 4, to October 27.

Tamiasciurus hudsonicus loquax Bangs. Red squirrel.—Four adults and a juvenile male were taken in Oglebay Park.

Sciurus carolinensis leucotis (Gapper). Eastern gray squirrel.—Two specimens were taken near Clinton, Ohio County, on September 6, 1949. A third specimen, an adult female showing no signs of pregnancy or recent parturition, was taken July 25, 1949, at Jackson's Mill, Lewis County.

Sciurus niger rufiventer (Geoffroy). Fox squirrel.—An adult male, agreeing with the characters of *rufiventer*, was taken at Clinton, Ohio County, on September 6, 1949.

Glaucomys v. volans (Linnaeus). Southern flying squirrel.—Four specimens were taken at Jackson's Mill, Lewis County, from July 21 to 27, 1949. Three were females; one carried four 18-millimeter embryos, one bore four 11-millimeter embryos, and the third contained three 18-millimeter embryos.

On November 7, 1949, two flying squirrels (one collected) were started from a bird house in Oglebay Park, Ohio County. The following day, five adults were frightened from another bird house in the park. The houses, measuring five by five by ten inches, were nailed about 12 feet high on the trunks of trees alongside a park drive.

Peromyscus leucopus noveboracensis (Fischer). White-footed mouse.—Represented by twenty specimens from the following localities: Oglebay Park, Ohio County, 6; Tomlinson's Run State Park, Hancock County, 7; Jackson's Mill, Lewis County, 4; three miles west of Bethany, Brooke County, 1; three miles east of Beech Bottom, Ohio County, 1.

Five lactating females were taken on March 10 and August 10, 21, and 22, 1949. Two pregnant females, one with four five-millimeter embryos, the other with five four-millimeter embryos, were taken July 22 and August 21, respectively.

Neotoma magister Baird. Allegheny woodrat.—My only specimen was taken from a shallow cave approximately four miles north of Hanging Rock, Hampshire County, on July 9, 1949.

Microtus p. pennsylvanicus (Ord). Meadow vole.—This species is represented by four specimens from Oglebay Park, Ohio County; one from three miles west of Bethany, Brooke County; and six from Tomlinson's Run State Park, Hancock County. In addition, I have examined eight specimens from Oglebay Park collected in 1928 and 1929 by Vernon Bailey. One female, collected August 21, 1949, in Hancock County, contained five six-millimeter embryos.

Ondatra z. zibethica (Linnaeus). Muskrat.—I have one specimen, a lactating female, found DOR in Oglebay Park, Ohio County, on August 1, 1949. Numerous tracks were observed in Tomlinson's Run State Park in August, 1949, but no specimens were taken.

Mus m. musculus Linnaeus. House mouse.—This species was frequently observed in Oglebay Park, Ohio County, but no specimens were taken. One specimen collected in 1929 was examined.

Rattus norvegicus (Berkenhout). Norway rat.—Occasionally seen in Oglebay Park, Ohio County, but none collected. One specimen taken in the Park in 1929 was examined.

Rattus r. rattus (Linnaeus). Black rat.—Seven specimens were taken from two groups of farm buildings four miles north of Hanging Rock, Hampshire County, on July 9, 1949.

Rattus rattus alexandrinus (Geoffroy). Roof rat.—Three specimens were secured from a granary four miles north of Hanging Rock, Hampshire County, on July 9, 1949 (Barbour, 1950*a*).

Zapus h. hudsonius (Zimmermann). Meadow jumping mouse.—We have a single specimen taken August 13, 1949, from a fencerow about one-fourth mile east of Oglebay Park, Ohio County.

Napaeozapus insignis roanensis (Preble). Woodland jumping mouse.—Brooks (1929) listed one specimen of *Napaeozapus i. insignis* from Oglebay Park, Ohio County. I have examined this specimen, an adult male taken January 28, 1929, by E. G. Hickman. It agrees in coloration with a series of *insignis* from New York.

My four specimens from Oglebay Park were taken in August, 1949. All agree with the characters of *roanensis*, and are inseparable from a series of *roanensis* from Harlan County, Kentucky.

Sylvilagus floridanus mearnsi (Allen). Eastern cottontail.—Two specimens, agreeing with the characters of *mearnsi*, were taken in Oglebay Park, Ohio County.

Odocoileus virginianus (Boddaert). Whitetail deer.—This species has been observed occasionally in Oglebay Park, Ohio County.

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ROGER W. BARBOUR, *Department of Zoology, University of Kentucky, Lexington, Kentucky.*
Received October 25, 1950.

REVIEW

Young, J. Z. THE LIFE OF VERTEBRATES. London: Oxford University Press, 776 pp. 1950.

To cover so broad a field in one book is a courageous undertaking, but this author deserves high praise for what he has done. As a text book, for a course in vertebrate zoology, it will serve a useful purpose. In his preface the author states that he has attempted to give a combined account of the embryology, anatomy, physiology, biochemistry, paleontology, and ecology of all vertebrates. Professor Young has shown good judgment in the treatment he has given the diversity of topics he has chosen in the limited space allotted to him.

The readers of this journal will be interested mainly in his discussion of mammals both living and extinct. The author has followed the classification of Simpson in a very abbreviated form, but the result makes stimulating reading and should give the student the essential foundation on which to broaden his knowledge of the subject. The author states in his preface that the space allotted is quite inadequate for the purpose of treating the structure, function, and development of mammals and that he intends to supplement this part with another volume. This will be a welcome supplement as there is great need for a modern text book to take the place of those of Flower & Lydekker, Weber, and Beddard. The beginning student, however, will have in Mr. Young's book a very good outline of these older texts brought up to date.

A few minor errors were noted: On page 619, the author speaks of the incisor teeth of rodents having enamel only on their interior surface. This should read "anterior." Two

statements on pages 622 and 624 regarding the infraorbital canal of hystricomorph rodents are contradictory and correctly stated only one page 624. It would be more exact to state on page 622 that in the hystricomorphs the infraorbital foramen is much enlarged for muscle transmission except in the Bathyergidae. On page 699 the statement that both even and odd toed ungulates develop a postorbital bar is somewhat misleading as there is none in the pigs.—William P. Harris, Jr.

RECENT LITERATURE

(Conducted by G. S. Miller, Jr., Emma Charters, D. H. Johnson, and R. H. Manville)

[Reprints of this section may be purchased from the Corresponding Secretary]

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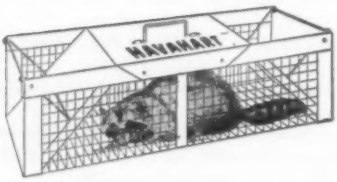
DATE OF ISSUE OF PREVIOUS NUMBER

JOURNAL OF MAMMALOGY, Vol. 32, No. 2, was mailed **May 21, 1951**

HAVAHART HUMANE ANIMAL TRAPS



Live traps for SMALL MAMMALS, as well as those for mammals as large as a raccoon, are now available from the *Allcock Manufacturing Company, Ossining, New York.* HAVAHART traps have been used successfully by many who have been doing live-trapping experiments on small mammals. A free booklet is yours for the asking.

THIRTY-FIRST ANNUAL MEETING

THIRTY-FIRST ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

JUNE 26–30, 1951

The thirty-first annual meeting of the American Society of Mammalogists was held at the Chicago Natural History Museum, Chicago, Illinois, June 26 to 30, 1951. Sessions were held in the James Simpson theatre of the Museum, with a trip on June 30 to the Chicago Zoological Park, Brookfield Zoo. A total of 96 members and guests registered.

The local committee on arrangements consisted of: Colin C. Sanborn, *Chairman*, D. Dwight Davis, Howard K. Gloyd, and Karl P. Schmidt.

PROGRAM

TUESDAY, JUNE 26

8:00 P.M.

Directors' Meeting, Stevens Hotel

WEDNESDAY, JUNE 27

9:00 A.M.

Registration

10:00 A.M.

Welcome. Colonel Clifford C. Gregg, *Director, Chicago Natural History Museum.*

Response. William J. Hamilton, *Vice-president, American Society of Mammalogists.*

1. A report on some vanishing mammals in Africa and Europe. Victor H. Cahalane, *National Park Service, Washington, D. C.*
2. Progress in conservation in the Pacific region. Harold J. Coolidge, *Pacific Science Board, Washington, D. C.*
3. The effects of Pleistocene Lake Bonneville upon speciation of mammals in Utah. Stephen D. Durrant, *University of Utah, Salt Lake City, Utah.*
4. Report on the status of the lynx in Canada 1940–1950. A. de Vos, *Department of Lands and Forests, Maple, Ontario.*

2:00 P.M.

Symposium on Predator-prey Relationship, Antoon de Vos, Chairman, *Department of Lands and Forests, Maple, Ontario.*

5. Introduction to the subject. A. de Vos.
6. Predation: A factor in dynamic ecology. Clifford C. Presnall, *Fish and Wildlife Service, Washington, D. C.*
7. The northern wolf and its prey. A. M. Stebler, *Laboratory of Vertebrate Biology, University of Michigan, Ann Arbor, Michigan.*
8. Timberwolf-white-tailed deer relationships. M. H. Stenlund, *Minnesota Department of Conservation, Ely, Minnesota.*
9. Some coyote-prey relationships. Edson Fichter, *Idaho State College, Pocatello, Idaho.*
10. Shrew predation and vole populations on a localized area. W. Robert Eadie, *Cornell University, Ithaca, New York.*

THURSDAY, JUNE 28

9:00 A.M.

11. Analysis of body proportions in canids. Milton Hildebrand, *Division of Zoology, University of California, Davis, California.* By title.

12. The vaculum and its taxonomic value in five species of chipmunks. John A. White, *University of Kansas, Lawrence, Kansas.*
13. Notes on the comparative ecology and geographic range of Massachusetts cottontails. Francis H. Fay, *University of Massachusetts, Amherst, Massachusetts.*
14. Data indicating forest rodent mortalities from brain infections with raccoon *Ascaris* larvae. Jack D. Tiner, *University of Illinois, Urbana, Illinois.*

10:00 A.M.

Annual Business Meeting

Election of Officers

12:00 NOON

Group Photograph

2:00 P.M.

15. Speciation and growth in the spotted cuscus, *Phalanger maculatus*. George H. H. Tate, *American Museum of Natural History, New York.* By title.
16. Mammal habitats in Cape York, Australia. Hobart M. Van Deusen, *American Museum of Natural History, New York.*
17. The harvest mice (genus *Reithrodontomys*) of Kansas. E. Lendell Cockrum, *University of Kansas, Lawrence, Kansas.*
18. Comparison of three methods of controlling *Microtus* in orchards. Don W. Hayne, *Michigan Agr. Exper. Station, East Lansing, Michigan.*
19. Reproduction of the Florida woodrat *Neotoma floridana*. W. J. Hamilton, Jr., *Cornell University, Ithaca, New York.*
20. The genital system and the fetal membranes as criteria of relationship between mammalian groups. H. W. Mossman, *University of Wisconsin.* By title.
21. Survival rates in the white-footed mouse, *Peromyscus leucopus*. Dana P. Snyder, *University of Michigan, Ann Arbor, Michigan.* By title.
22. Prolongation of clotting time in aestivating mammals. Arthur Svihla, *Department of Zoology, University of Washington, Seattle, Washington.*
23. The biology of the Arctic ground squirrel, *Citellus barrowensis*. Charles Wilber and J. Musacchia, *Saint Louis University, Saint Louis, Missouri.* By title.

4:00 P.M.

A Tea for the Ladies, Room 523, Stevens Hotel

6:30 P.M.

Annual Banquet

Museum Cafeteria, Chicago Natural History Museum

8:15 P.M.

"Into Central Australia." Alfred M. Bailey, Denver Museum of Natural History

FRIDAY, JUNE 29

9:00 A.M.

24. Variation in fall breeding of deer mice. E. W. Jameson, Jr., *Division of Zoology, University of California, Davis, California.*
25. Ability of *Peromyscus* to hear ultrasonic sounds. Lee R. Dice, *Institute of Human Biology, University of Michigan, Ann Arbor, Michigan.* By title.
26. Population density and social organization in howling monkeys. N. E. Collias and C. Southwick, *University of Wisconsin.*
27. Growth and development in *Peromyscus californicus*. Arthur Svihla, *Department of Zoology, University of Washington, Seattle, Washington.*

28. Some seasonal histological changes in the reproductive organs of *Ochotona princeps*. Kenneth L. Duke, *Duke University, Durham, North Carolina.*

11:00 A.M.

Final Business Meeting

2:00 P.M.

29. Life history of the mongoose in Hawaii. Paul H. Baldwin, *Colorado A. and M. College, Fort Collins, Colorado.*

MOTION PICTURES

30. Survival perilous, a story of the woodland caribou. Randolph L. Peterson, *Royal Ontario Museum of Zoology, Toronto, Canada.*
31. The social structure of a prairie dog colony in the Black Hills of South Dakota. John A. King, *University of Michigan, Ann Arbor, Michigan.*
32. Porcupettes. Albert R. Shadle and Robert D. Weigel, *Biology Department, University of Buffalo, Buffalo, New York.* 25 minutes.
33. Rare Hawaiian seal on Midway. Alfred M. Bailey, *Denver Museum of Natural History, Denver, Colorado.*
34. Field studies of animal locomotion. D. Dwight Davis, *Chicago Natural History Museum, Chicago, Illinois.*

6:30 P.M.

Buffet Supper and Smoker, Chicago Natural History Museum

SATURDAY, JUNE 30

The Members of the Society were guests of the Chicago Zoological Society at the Brookfield Zoo. Lunch was served at the Zoo.

BUSINESS MEETINGS

The meeting of the Board of Directors was called to order by William J. Hamilton, Jr., Vice-president. President Tracy I. Storer and Vice-president Lee R. Dice were absent because of illness, and messages of condolence were sent both. Lee S. Crandall was reelected a Trustee for the period 1951–1954 and William H. Burt was reelected Editor. Budgetary allotments for the year were made and the Society's memberships in the International Union for the Protection of Nature and the American Institute of Biological Sciences renewed.

The annual business meeting on June 28 was attended by 46 members. The following officers were elected: William J. Hamilton, Jr., President; William H. Burt and William B. Davis, Vice-presidents; Robert T. Orr, Recording Secretary; Donald F. Hoffmeister, Corresponding Secretary; and Viola S. Shantz, Treasurer. Stanley P. Young was elected to the vacated but unexpired term of William B. Davis, Director, 1950–1952. Directors for the term 1951–1953 were elected as follows: Victor H. Cahalane, Emmet T. Hooper, J. Kenneth Doutt, W. Robert Eadie, and Antoon de Vos.

It is with deep regret that the Society learned of the deaths of 8 members during 1950, two of whom were Life (†) Members and three of whom were Charter (*) Members: †* Annie M. Alexander, Rudolf Bennitt, Kenneth Cook, E. C. Cross, * Frederick M. Dille, † Albert J. B. Kirn, Glenn C. Rinker, * Chester Stock.

The year 1950 closed with a record high of 1708 members and subscribers. There were 130 nominees for membership, including one life membership, 26 resignations, 8 deaths, and 30 dropped from the roles for being in arrears in dues for three years. The only lag during the year was in the category of life members. Members and nominees are urged to consider obtaining life memberships.

The By-laws were amended, by unanimous vote, from the present wording: Article VIII, "*Sec.* 2. Any member upon payment of one hundred dollars at one time shall be entitled

to life membership, and shall be exempt from membership dues." to read, "*Sec.* 2. Any member upon payment of one hundred dollars at one time, or in four payments of twenty-five dollars in four consecutive years, shall be entitled to life membership, and shall be exempt from membership dues from the time of the initial payment."

Cost for printing the Journal of Mammalogy from 1946 through 1950 has increased 39 per cent, and this more than offsets the 33 per cent increase in membership dues imposed in 1949. The desirability of lithoprinting or printing of the proposed 10-year index was discussed, but no decision was reached.

The reports of the Corresponding Secretary, Recording Secretary, Treasurer, and Trustees, were read and accepted. Reports of the following committees were read and accepted: Conservation of Land Mammals (Ralph Palmer); Bibliography (David Johnson); Marine Mammals (Robert Orr); Economic Mammalogy (E. R. Hall); Nomenclature (E. T. Hooper); Membership (A. R. Shadle); Editorial (W. H. Burt); Index (V. S. Schantz); Means of Encouraging Young Mammalogists (David Davis); Dues Status of Retired Mammalogists (A. R. Shadle). Reports of representatives to other societies were presented.

The Corresponding Secretary submitted the following summary of memberships, subscriptions, and mailing for the year ending December 31, 1950.

SUMMARY OF MEMBERSHIPS AND SUBSCRIPTIONS FOR 1949 AND 1950

	1949		*1950*	
MEMBERSHIP				
Changes since preceding annual report				
Nominees		169		130
Resignations	27		26	
Deaths reported	16		8	
Members dropped (delinquent)	18		30	
Total		61		64
Net Change		+108		+66
Status as of December 31				
Honorary members	3		3	
Life members	49		48	
Annual members	1180		1247	
Total membership		1232		1298
SUBSCRIPTION				
Changes since preceding report				
New subscriptions	44		45	
Subscriptions cancelled	31		18	
Net change		+13		+27
Status as of December 31				
Total paid subscriptions		383		410
MAILING LIST				
Total membership	1232		1298	
Members not receiving Journal	129		126	
Total members receiving Journal		1103		1172
Total paid subscriptions		383		410
Total mailing list		1486		1582
Net change from preceding year		+118		+96

FINAL BUSINESS MEETING

The final business meeting held June 29 was attended by 43 members. For distinguished services to mammalogy, two persons were unanimously elected to honorary membership: A. Brazier Howell and T. S. Palmer.

The following recommendation was adopted by the Society:

> In order to encourage young mammalogists and to stimulate research, the American Society of Mammalogists will provide honoraria so that young students may attend the annual meeting.
>
> Each year the Society will make an appropriation not to exceed $200 for this purpose.
>
> The funds shall be awarded by a committee of three, appointed annually by the president of the Society, to as many young mammalogists as circumstances permit.
>
> The award need not be given unless a worthy candidate is available.
>
> Each honorarium shall amount to $50.
>
> The recipient(s) shall be notified at least one month before the meeting and shall then receive the funds.
>
> The award shall be made on the basis of a papar submitted to the committee for presentation by the candidate at the annual meeting.

The following recommendation was adopted by the Society:

> That a new grade, *Emeritus Membership*, hereby be established.
>
> That upon their request, individuals who have been for twenty-five (25) years members in good standing of the American Society of Mammalogists, shall be eligible for such Emeritus Membership.
>
> That when a member is eligible for Emeritus Membership, and is in arrears for dues, the Corresponding Secretary shall notify the member, indicating that it is necessary for him to request such change in his membership rank.
>
> Emeritus Membership *will not carry with it* (a) the right to vote, nor (b) the right to receive the Journal free.
>
> At each annual meeting, the Corresponding Secretary shall report to the Board of Directors, for their approval, the names of the members who are to be added to the Emeritus Membership List.
>
> That if any changes in By-laws are necessary, immediate steps be taken to expedite the activation of this report, and its recommendations.

The following resolutions were unanimously passed:

Whereas the Chicago Natural History Museum, its entire staff, and the chairman and members of the local committee, particularly Colin C. Sanborn, and

Whereas the Chicago Zoological Society, particularly Robert Bean, have provided arrangements, facilities, and entertainment which have contributed greatly to the success of the Thirty-first Annual Meeting of this Society and of the attending members.

Therefore be it resolved that the American Society of Mammalogists extends to the Chicago Natural History Museum, the Chicago Zoological Society, and the local committee its sincere thanks and hearty appreciation.

Whereas a proper utilization of wildlife resources is of considerable importance to human populations, and

Whereas the survival of wildlife at reasonable population levels is closely tied up with a land-use system based on sound ecological principles, and

Whereas with augmenting human populations, increased distortions are noticeable in the dynamic balance between predators and their prey, and predator control has become necessary under certain conditions, and

Whereas there is need for more emphasis upon studies of the impact of man's modification of ecological conditions upon wildlife conditions,

Therefore, be it resolved by the American Society of Mammalogists in annual convention at

Chicago, Illinois, on June 29, 1951, that the Society will approach universities and other institutions dealing with wildlife conservation, will encourage them to arrange for more research work on those phases of animal ecology related to man's activities, and will request them to suggest what steps might be taken in that direction.

Whereas the American Military Government in the American Zone of occupied Germany allows exploitation of wildlife, with few minor restrictions, by occupation personnel without regard to ownership, lease, or other property rights in wildlife—in effect, a policy of no licenses and no bag limits, and

Whereas those in authority have not heeded conservation proposals in this regard from informed groups in Europe.

Therefore, be it resolved that the American Society of Mammalogists at its Thirty-first Annual Meeting expresses strong disapproval of this policy of unlimited exploitations and urges that it be rescinded immediately.

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